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fuel cell work

48p.

(NASA contract NAS3-2551)

ti MONTHLY PROGRESS REPORT

N64-16282

No. 8

CODE-1

~~for~~ 6

(NASA CR-55695) OTS:

month 15 Mar. 1963 February, 6 1963 [Development...]

Submitted by

48 p refs

NEW PRODUCT RESEARCH of TAPCO

OTS PRICE

XEROX $ 4.60 ph

MICROFILM $ 1.64 mf

Monthly Progress Report No. 8
March 15, 1963

I INTRODUCTION

This document represents the eighth monthly report covering the work on the experimental program for development of an "Osmotic Still" and improvements in the performance characteristics of the Ionics Dual Membrane Fuel Cell during the month of February 1963. This development work is being accomplished under NASA-Lewis Research Center Contract No. NAS 3-2551 by the New Product Research Department of TAPCO, and Ionics Inc. as a subcontractor to TAPCO.

II OVERALL PROGRESS

A. Tapco Portion of Program

1. Ionac membranes MC 3142, MA 3148, XLMA 3236, and XLMC 3235 were tested for liquid leakage at room temperature after being soaked in water at toom temperature for 16 hours. All but the XLMC 3235 showed no leakage with a pressure difference of 16 psi. The XLMC 3235 leaked with a 15 psi pressure difference.

2. The same membranes were pressure tested at room temperature after being pretreated in 180°F (recommended by Ionac) water for four hours. All membranes leaked excessively at pressures differences from 2 to 10 psi.

3. Performance tests were attempted with the MC 3142 and the MA 3148. The MC 3142 was pretreated in 180°F water before installation and excessive leakage occurred immediately upon evacuation of the vapor chamber before acid heatup.

The MA 3148 was run for approximately four hours at temperatures of 125°F and 140°F, but extremely small amounts of liquid were extracted during this period and a ph1 was never exceeded. Thus, the above Ionac membranes were determined unsuitable and testing of these membranes was discontinued.

4. Five successful test runs were completed with the AMF C-60 membrane at temperatures from 150°F to 200°F and at vapor pressures from .45 psia to 1.23 psia with an acid concentration of 25.2%.

5. A total of 15 successful test runs were made with the AMF C-60 membrane at 200°F and acid concentrations from 15.2% to 60%.

6. Two tests on this membrane were made with acid pressures of 26 psia and 32 psia at 200°F and 25.2% concentration.

7. The AMF C-60 membranes used in the tests during this reporting period are the same membranes used during the last reporting period and the Kel-F coated support screens have been used throughout all the tests and appears to be in good condition.

8. Porous Kel-F and porous polyethylene were leak tested as non-wetting materials, but were determined as unsatisfactory.

B. Ionics Portion of Program

1. Progress was made in the areas of test rig control and operation, membrane and electrode screening, successful life testing, delineation of the source of liquid in the cell gas streams, determination of the effect of gas circulation rates on cell performance, finalizing the design of and expediting procurement of materials for the multiple cell batteries.

2. Revamping of test rig controls and operation has led to successful long-term tests of fuel cells without any premature failures.

3. Continued screening tests in small (4 sq. in.) test cells reinforced the finding that we are now using the best membranes (IONICS 61-AZG and 61-AZL) and electrodes (platinum black sintered with teflon) that are available.

4. Long successful runs of single cells - up to 500 hours and still running - have been achieved while meeting the electrical output requirements.

5. The liquid appearing in the gas streams was shown definitely to have come through the membranes. Rates of liquid appearance were determined.

6. Wide variation in gas rates was shown to have no effect on cell output, thus simplifying eventual system control problems. The pressure drop through a single cell was shown to be small even at gas circulation rates 20 times the consumption rate - indicating that power losses for gas circulation will not be serious.

7. Design modifications based on our findings were made and finalized design drawings for multiple-cell battery components prepared. Procurement and fabrication is in full swing.

II. CURRENT PROBLEMS

A. Tapco Portion of Program

There have been no major problems during this reporting period.

B. Ionics Portion of Program

1. Delivery of ordered materials and fabrication of components needs additional expediting.

IV NEXT MONTH'S EFFORT

A. Tapco Portion of Program

1. Complete performance tests on the AMF C-60 membrane.

2. Select design point for 2 KW still design and make preliminary gasket tests for 2 KW design.

3. Design 2 KW still and test rig.

B. Ionics Portion of Program

1. Expedite receipt of ordered materials.

2. Complete fabrication of all components for 5-cell batteries.

3. Complete modifications to test rig to permit testing 5-cell batteries.

4. Finalize technique for assembling, venting and filling multiple-cell batteries.

5. Assemble initial two 5-cell batteries.

V TEST RESULTS

A. Tapco Portion of Program

1. The initial test with the Ionac MC 3142 membrane was made in the test unit after the membranes had been soaked in 180°F water for four hours (recommended by Ionac representative). Upon initial evacuation of vapor chamber prior to acid heatup, the membrane leaked acid excessively with a vacuum of only 20 cm mercury. Upon removal of the membrane from the test unit, inspection showed no rupture in the membrane.

2. Leakage tests were made on the Ionac membranes after soaking in room temperature water for 16 hours. These tests were made by securing the membrane over a 3/8" diameter hole and exposing one side of the membrane to pressurized water and the other side of the membrane to atmospheric air. Leakage was determined by visual observation. The water pressure was gradually increased to determine where leakage was visible.

Membrane	Water Pressure	Pressure Duration	Results
MC 3142	16 psig	16 hrs	No leakage
MA 3148	16 psig	1 hr	No leakage
XLMA 3236	16 psig	1 hr	No leakage
XLMC 3235	15 psig	1 hr	Small leakage at first but increased with time

3. Leakage tests were made on the same membranes after soaking in 180°F water for four hours.

Membrane	Water Pressure	Results
MC 3142	2 psig	Rapid leakage
MA 3148	10 psig	Small leakage
XLMA 3236	8 psig	Rapid leakage
XLMC 3235	3 psig	Rapid leakage

4. Leak tests were made on two non-wetting porous materials. A sample of porous Kel-F sheet with pore size under 7 microns and a sample of porous polyethylene sheet with pore size under 2.0 microns were obtained from the ESB Reeves Corporation. The tests were made with water at room temperature.

Sample	Results
Porous Kel-F	Leaked at 7 psig
Porous Polyethylene 13-CN	Leaked at 3.5 psig

5. Attached are plotted data obtained on the AMF C-60 to date. (TRW Fig. 1A) Also, attached are performance test raw data for this reporting period.

B. Ionics Portion of Program

1. Test Rig Revamp

Many cells previously had to be taken off test prematurely due to malfunction of the test rig control system. The test rig and test procedures were revamped and no premature (less than 100 hour) malfunction has occurred since. The major changes included:

1. Operation at 5 psig instead of 15 psig.

2. Additional instrumentation to ensure that the pressure in each gas compartment and each electrolyte compartment was 5 $\pm$ 0.3 psig.

3. Gas manifold changes to ensure that gas pressure remained constant during gas supply changes.

4. Additional operator instruction to ensure that the pressure differential between gas and electrolyte compartments did not exceed 1.5 psi during startup.

5. All tygon tubing in the oxygen system has been replaced with polyethylene to prevent the occasional fires which had been noticed in these lines.

2. Single 4 sq. in. Cell Studies

2.1 Membrane Studies

The effect of various membranes on cell resistance was investigated at Ionics and as part of a subcontract at Arthur D. Little. In addition, the appearance rate of liquid in the gas compartments was measured in the cells tested at Ionics.

Six different types of membranes were studied at Ionics: 61AZG (Ionics Standard), 61-DYG, 61-AZL, 61-AZL-15, 61-AZL-8, and AMF-C313. The 61-AZG, AMF C-313 and AMF C-60 were studied at A.D.L. Hydrogen and oxygen were bubbled through 6N H_2SO_4 prior to being fed to the cells so as to saturate the gases with water vapor. Liquid coming out of the two gas compartments was collected in small graduated cylinders. Standard sintered electrodes were used in these cells. Results obtained are summarized in Table 1. The relative cell resistances were obtained from the slope of current vs. voltage plots. All the cells were run at a current of 400 ma, except when current vs. voltage curves were being obtained. Cells containing 61-AZL and 61-AZG showed the lowest resistance - 0.26 and 0.31 ohms, corresponding to cell specific conductances of 138 and 116 mhos/ft^2. This may be compared to values up to 140-180 mhos/ft^2 found for the 36 sq. in cells. The larger cells may be showing a higher specific conductance because the electrolyte compartments are thinner:

0.060" in the 36 sq. in. cells vs. 0.625" in the 4 sq. in. cells. The amount of liquid collected was very low and varied from negligible to 1.5 ml per day compared to 3.2 ml/day produced from the fuel cell reaction.

Overall, 61-AZG appears the most desirable membrane with 61-AZL a possible second. The AMF membranes had previously shown considerably poorer stability than 61-AZG or 61-AZL on continued exposure to 6N sulfuric acid at elevated temperatures.

2.2 Electrode Studies

Several different types of electrodes were tested at Ionics and under subcontract at Arthur D. Little.

2.2.1 Clevite Electrodes

Clevite Corporation made two electrodes (sintered type) using a lighter grade of M_gO powder in the paste. Performance of these electrodes was very poor and voltages were taken only at 0.4 and 0.67 amps.

	VOLTS		
AMPS	TOTAL	H2	O_2
0.4	0.407	0.147	0.263
0.67	0.313	0.100	0.207

These voltage readings were considerably lower than voltages obtained from the sintered electrode used before: e.g., 0.76 total volts at 0.4 amps. These new electrodes were pressed at a very high pressure (10,000 psi compared to our normal 4000 psi). This might have caused low porosity, resulting in low meter readings.

2.2.2 Mott Electrodes

Mott Metallurgical Corporation prepared sintered platnimum black electrodes. These are circular and have an area of 2.95 sq. in. A characterization curve is shown in Figure 1. The values obtained here are also very low: 0.4 total volts at 0.4 amps. The cell had a specific conductance of 120 mhos/ft2. The oxygen electrode was sprayed with teflon and then tried in the cell. The performance of this cell was even poorer than the above. Current more than 80 ma could not be drawn.

2.2.3 Imprinted Electrodes (ADL)

It appeared first that a technique of imprinting the membrane with Pt black would improve the catalyst membrane contact as experiments of this type had been performed by Gregor[1], [2] with some success. Series 100 AMF membranes had been subjected to 60,000 psi and 115°C to imbed Pt black and had performed well in single membrane cells with no free electrolyte. However, further experiments reported by Perry[3] in which imprinted cation membranes were used in a dual membrane alkaline cell gave polarization curves no higher than those reported by Lurie et al.[4] for similar cells with unimprinted Ionics membranes. Attempts to imprint both Ionics and AMF membranes at lower temperatures (to prevent membrane drying) had proved unsuccessful and were discontinued in the light of Perry's report.

2.2.4 Deposited Electrodes (ADL)

Chemical reduction of platinum compounds to metal in and on the membrane was attempted in an effort to put more active catalyst in intimate contact with the membrane. The soluble Pt (NH_3) Cl_2 complex was prepared by treating a chloroplatinic acid solution with excess ammonia and the membrane surface washed with this solution. The membrane was then flushed with a basic solution of sodium borohydride, reducing the complex to finely-divided platinum and various soluble salts. While a darkening of the membrane was observed which could be attributed to the presence of platinum, it was not possible to build up any appreciable concentration at the surface of the membrane, the only area in which it would be accessible to gaseous H_2 and so useful as a catalyst.

An attempt was also made to use this impregnated membrane as a cathode and deposit upon it electrochemically Pt black from standard platinizing solutions. This also proved unsatisfactory as no significant current density could be obtained, showing that even with reduced platinum present, the surface of the membrane was still not the electronic conductor required for this technique.

2.2.5 Pure Platinum Electrodes (ADL)

The presence of Teflon in the Pt paste has seemed a possible source of trouble as it places an electrically insulating material in the electrode-catalyst region. Taschek and Wynn (5) report that it may introduce as much as 70 mv additional ohmic polarization when used as wet-proofing material in place of the more common but less durable paraffin. A fuel cell was prepared in which a thin layer of pure Pt black was sandwiched between membranes and electrodes, the electrodes having been well coated with Pt black electrochemically. The polarization curve is shown in Figure 2. After four days it showed no deterioration due to lack of wet-proofing although this would certainly have become a problem at a later time. The conclusions to be drawn from these curves is that at the low current densities concerned, about 700 ma for the small cell, voltage loss is due in overwhelming part to the initial electrode polarization and efforts to reduce the limiting slope have little effect upon the immediate application of the cell. Reports from Ionics concerning a cell with teflon present primarily on the oxygen side give a limiting slope of about 0.2 ohms for the cell but a voltage at 700 ma again of about 0.65 v, the same voltage is obtained both with and without teflon. The problem is thus one of catalysis rather than internal resistance of the cell components. Further work should then be concerned with this problem.

2.2.6 Platinized Carbon Electrodes (ADL)

As one step toward investigation of the catalysis problem, a pair of platinized carbon electrodes were prepared according to the method of Taschek and Wynn[5]. Two 2' x 2" x 3/32" pieces of PC 57, manufactured by the Stackpole Carbon Company, were chosen. This material has a porosity of 1.07 cc/g and surface area of about $300 M^2/g$. Pores range from 3 to 7 microns in diameter. These blocks were wet-proofed by soaking in a solution of 2 g paraffin in 100 ml petroleum ether, dried, and then heated to 200°C for two hours. While still hot, they were painted with a 10% solution of H_2PtCl_4, using enough solution for a coverage of 2 mg Pt/cm^2. They were then dried in an oven at 100°C for several hours and transferred to a vacuum oven at 150°C for five more hours to decompose the platinum compound.

The prepared carbon was put into the cell with the treated surface against the membrane and electrical contact was made by platinum gauze pressed against the back of the carbon. Resistance of the assembled cell was 0.4 ohm, measured with a Kiethyley Model 502 Multiohmeter. A polarization curve for this electrode system is also shown in Figure 2.

2.2.7 Bibliography for ADL Electrode Study

1. H. P. Gregor, "Fuel Cell Materials," Fifth Quarterly Progress Report, Contract No. DA-36-039 SC-85-85384.

2. H. P. Gregor, "Fuel Cell Materials," Final Report, Contract No. DA-36-039 SC-85384.

3. J. Perry, Jr., Proceedings 16th Annual Power Sources Conf. (1962).

4. R. M. Lurie, C. Berger and R. J. Schuman, "Fuel Cells," Vol. 11, Reinhold, p. 143, (1963).

5. W. G. Taschek and J. E. Wynn, Proceedings 16th Annual Power Sources Conf. (1962).

3. Single 36 Sq. In. - Cell Studies

Two cells with tantalum pusher and separator plates are operating very well at 5 psig. For one of these cells, the effect of wide variations in gas rates on pressure drop and polarization curves were determined. The rate of liquid appearance in the gas compartments was also checked. Two unusual cells were placed on stream to help pin down the source of the liquid found in the gas compartments.

Detailed results are given in Table 2.

3.1 Effect of Pressure Level

Cell E-1282 and Cell E-1268 were identical cells except that E-1268 was run at a nominal 16 psig and E-1282 at a nominal 5 psig. As reported last month, when 4 amps were drawn from E-1268, the cell voltage did not maintain its initial value of 0.79 v but fell to 0.632 v in 120 hours. The lower pressure E-1282 on the other hand maintained voltage very well - reading 0.748v after 288 hours. This improved voltage maintenance was ascribed to smoother operation of the cell at the lower pressure level. Unfortunately, the hydrogen flow path became obstructed after approximately 300 hours: hydrogen would no longer flow through the cell and the cell failed. Inspection of the cell after dismantling did not disclose the nature nor exact location of the blockage.

3.2 Effect of Well-Balanced Pressures

In view of the improvement in operation obtained by reduction of the pressure level (Cell E-1282), a cell was put on stream with particular effort to keep inter-compartment pressure differences during startup and operation to a minimum (Cell E-1651). This cell has maintained a voltage of close to 0.8v at 4 amps for over

500 hours. The polarization curves obtained after 168 hours are produced in Figure 3. Note that the hydrogen electrode suffers from "concentration polarization" at about 50 amps/ft^2 while the oxygen is unaffected at this current density. The tantalum pusher and separator plates in this cell appear to be giving excellent service.

The specific conductance of the cell showed a continuing slow decrease with time, as have all other cells. It is not currently clear whether this is due to gradual membrane fouling, electrode deterioration or some other degradative process.

3.3 Source of Liquid in Gas Compartments

To determine the source of the liquid observed in the gas chambers and in the gas outlet lines in a qualitative way, two unusual cells were built. The first cell (E1279) had non-permeable pieces of rubber in place of membranes. This would allow leakage from the electrolyte ducts, hopefully to the same extent as in the regular cell, but would prevent transport of liquid through the membrane.

The second cell (E-1652) had an electrolyte chamber isolated from the gas compartments so that liquid could only reach the gas compartments by passing through the membrane. Liquid collection bottles were provided for all exiting gas streams of both cells.

After three weeks operation, the quantity of acid found in the collection bottles of the cell with the impermeable membrane-substitutes was equivalent to only 4 cc of electrolyte on the oxygen side and 12 cc on the hydrogen side. This demonstrated that with the present gasketing system, the acid leakage between compartments by way of the manifolds, ports, etc., can be kept to negligible levels. On the other hand, the collector bottles on each of the gas streams leaving the cell with the external electrolyte flow circuit (E-1652) had collected several hundred cc's of liquid during the same three week period. The liquid had definitely passed through the membrane.

3.4 Rate of Liquid Appearance

The rate of liquid production from the gas compartments were measured on cell D9228. These data are presented in Figure 4. The average sulfuric acid concentration in the liquid collected in the hydrogen side is 6N and in the oxygen side is 4.5N. The data presented are after 24 hours of operation when the cell had achieved reasonably steady operation. By taking the slope of the curve, an average value for the rate of liquid production can be obtained. The hydrogen side curve produces a consistent 0.6 ml/hr; the oxygen side was less consistent (possibly due to intermittent liquid holdup) but an average value of 0.63 ml/hr can be obtained. The rate of water production by reaction is 1.35 ml H_2O/hr.

3.5 Effect of Varying Gas Rates

Pressure drops across the gas compartments were measured for various gas flow rates in cell D9228. These data appear in Figure 5. At 5 psig and 25°C, the cell uses 22 ml/min of hydrogen and half the quantity of oxygen at four amperes. At twenty times these gas rates, the pressure drops were only 30 mm H_2O on the O_2 side and 20 mm H_2O on the H_2 side. The energy loss even at very high gas recycle rates would thus be quite low. Polarization curves were also measured on cell D9228 with carefully controlled flow rates to determine the influence of gas flow rate on cell performance. Flow rates of 140 and 500 ml/min on the hydrogen side, and 50 and 200 ml/min on the oxygen side were compared. The polarization curves, Figure 6, show no detectable difference up to a total current of 10 amperes (40 amp/ft^2). These measurements will be extended to 25 amperes.

4. Multi-Cell Battery Design Modifications

In the light of results with single cells, design modifications have been made in the radial porting of the gas and electrolyte compartments.

4.1 Gas Compartments

In the case of the gas compartments, the object has been to reduce the chance of gas-electrolyte leakage and to obtain better gas distribution to the parallel-connected cells. To this end, the minimum distance between the radial gas ports and the electrolyte port has been increased from 5/16" to 1/2". In addition, the number of inlet ports has been reduced to one, and its width reduced from 0.060 in. to 0.030 in. with the object of producing a higher hydraulic pressure drop and thus better gas distribution.

4.2 Electrolyte Compartment

With these components, the cut-and-cover technique for forming the radial electrolyte channels has been replaced by drilling a simple hole. It has proved difficult to maintain surface smoothness tolerances with the previously used, glued compartments. To permit the use of a drilled port it has been necessary to increase the thickness of the compartment from 0.060" to 0.100". In the case of the exit channel at the top of the cell, two parallel holes have been included to reduce the possibility of blockage by a gas bubble. (See Drawing number 2). A single inlet port with a cross-sectional area of about 0.0008 sq. in. will replace the two former inlet ports which had a joint cross-sectional area of 0.0036 sq. in. This was done to increase the hydraulic resistance and thus the efficiency of electrolyte manifolding.

5. Multiple-Cell Battery Component Procurement

5.1 Gas and Electrolyte Compartments

It has been decided to make at least one 5-cell battery out of Halon and one out of Penton. Because of the long delivery period for the non-standard thickness required for the electrolyte compartment, sufficient material has been ordered to permit the construction of a 10-cell battery in either plastic. Delivery has been promised for 15 March 1963.

5.2 Gasketing

From corrosion studies, it is expected that Dacron-reinforced Viton will prove to be a superior gasketing material. However, it has not been employed extensively in single cells as has Buna N. For this reason, it has been thought advisable to have a reserve stock of Buna N gaskets, which, though not ideal, would be expected to last the 100 hour life requirements of the batteries.

5.3 Electrode Manufacture

New plattens have been designed and materials ordered for their fabrication. The new plattens will permit the making of electrodes with one pressing operation in place of two, thus presumably permitting production of more reproducible electrodes.

5.4 Pusher and Separator Plates

Corrosion studies have shown tantalum to be the most resistant metal (other than platinum) to corrosion in 6N H_2SO_4. However, both niobium and zirconium have promisingly low corrosion rates. Since both these metals are less costly and lighter than the tantalum, it was decided to assemble at least one 5-cell battery containing some cells made with each metal.

5.5 General Status

The present state of procurement situation is summarized in Table 3. The technical task status and schedule is appended to the letter regarding manhours, dollar expenditures and commitments attached to this report.

Fig. TRW 1A

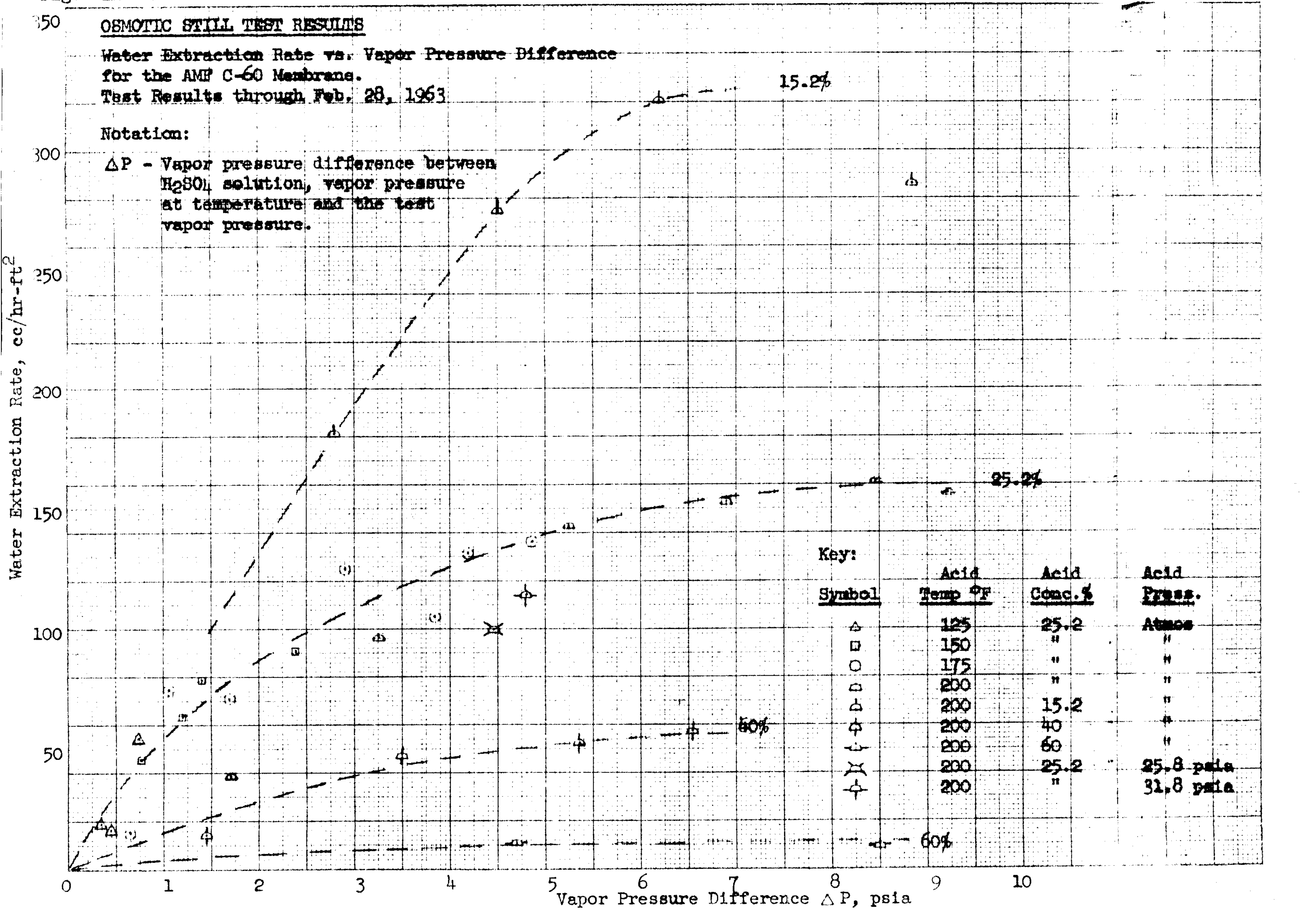

OSMOTIC STILL TEST RESULTS
Water Extraction Rate vs. Vapor Pressure Difference
for the AMF C-60 Membrane.
Test Results through Feb. 28, 1963
Notation:
ΔP - Vapor pressure difference between
H2SO4 solution, vapor pressure
at temperature and the test
vapor pressure.
15.2%
25.2%
60%
60%
Key:
Symbol
Acid Temp °F
Acid Conc.%
Acid Press.
125
150
175
200
200
200
200
200
200
25.2
"
"
"
15.2
40
60
25.2
"
Atmos
"
"
"
"
"
"
25.8 psia
31.8 psia
0
50
100
150
200
250
300
350
Water Extraction Rate, cc/hr-ft2
0
1
2
3
4
5
6
7
8
9
10
Vapor Pressure Difference ΔP, psia

TABLE I

MEMBRANE STUDY - 4 SQ. IN. CELLS - 25°C

Cell No.	Membrane Type	Cell Resistance Ohms	Cell Specific Conductance $mhos/ft^2$	Liquid Collected, mls/day	
				H_2 Side	O_2 Side
E 0224	61-AZG	0.31	116	negligible	0.13
ADL-11	61-AZG	0.27	135	*	*
E 1325	61-DYG	0.45	80	0.14	0.29
E 1327	61-AZL	0.26	138	1.44	2.6**
E 1326	61-AZL-15	0.45	80	0.56	1.17
E 1330	61-AZL-8	0.38	95	0.16	0.12
E 1331	AMF-C-313	0.33	109	0.03	0.03
ADL-12	AMF-C-313	0.35	104	*	*
ADL-13	AMF-C-60	0.38	95	*	*

* Not measured at A.D.L.

** On dye test, the membrane showed a pinhole.

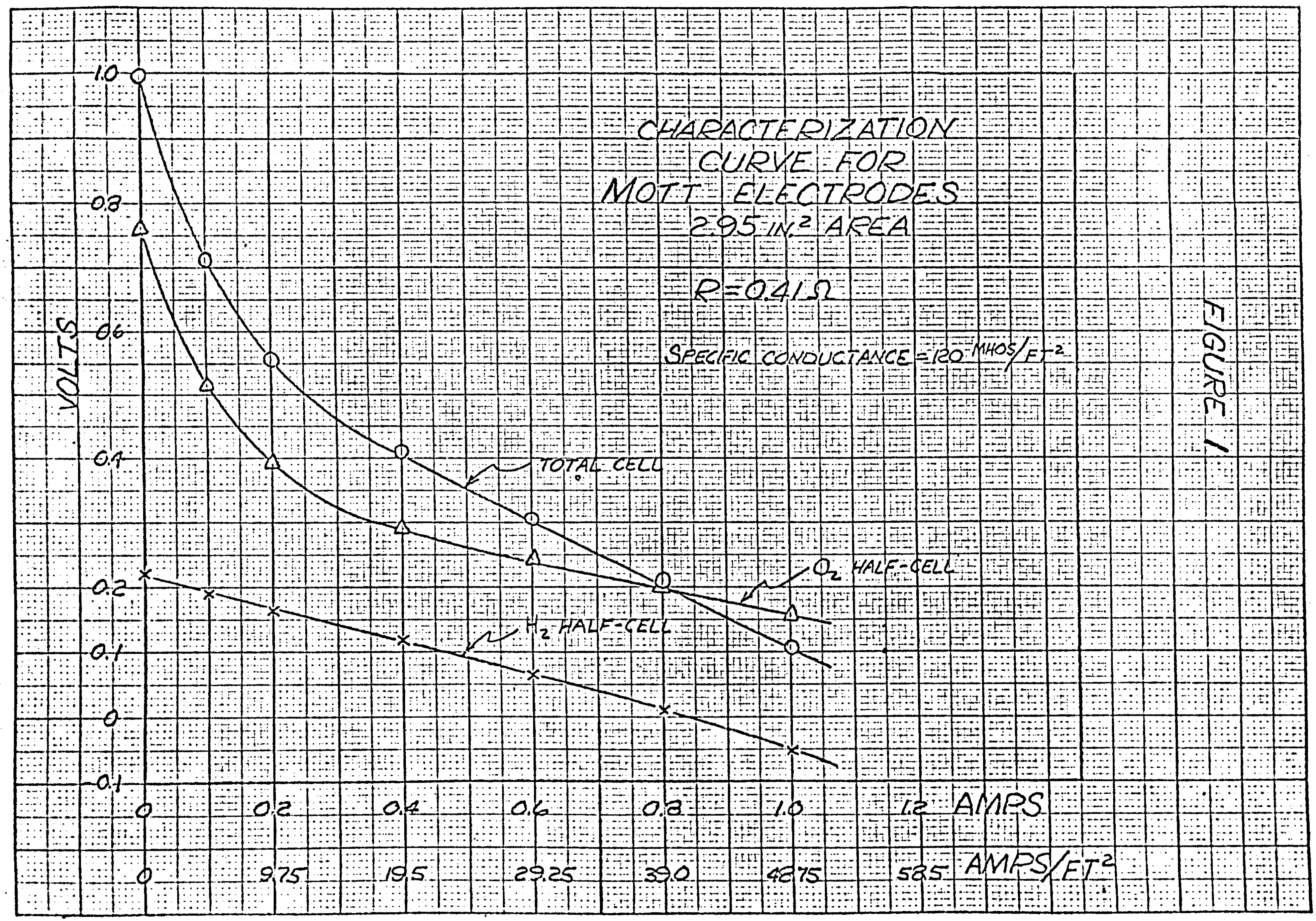

CHARACTERIZATION
CURVE FOR
MOTT ELECTRODES
2.95 IN.^{2} AREA
R=0.41Ω
SPECIFIC CONDUCTANCE = 120 MHOS/FT^2
TOTAL CELL
O_2 HALF-CELL
H_2 HALF-CELL
VOLTS
1.0
0.8
0.6
0.4
0.2
0.1
0
-0.1
0
0.2
0.4
0.6
0.8
1.0
1.2
AMPS
0
9.75
19.5
29.25
39.0
48.75
58.5
AMPS/FT^2

FIGURE 1

20 X 20 TO THE INCH
KEUFFEL & ESSER CO.
353-10½
MADE IN U.S.A.

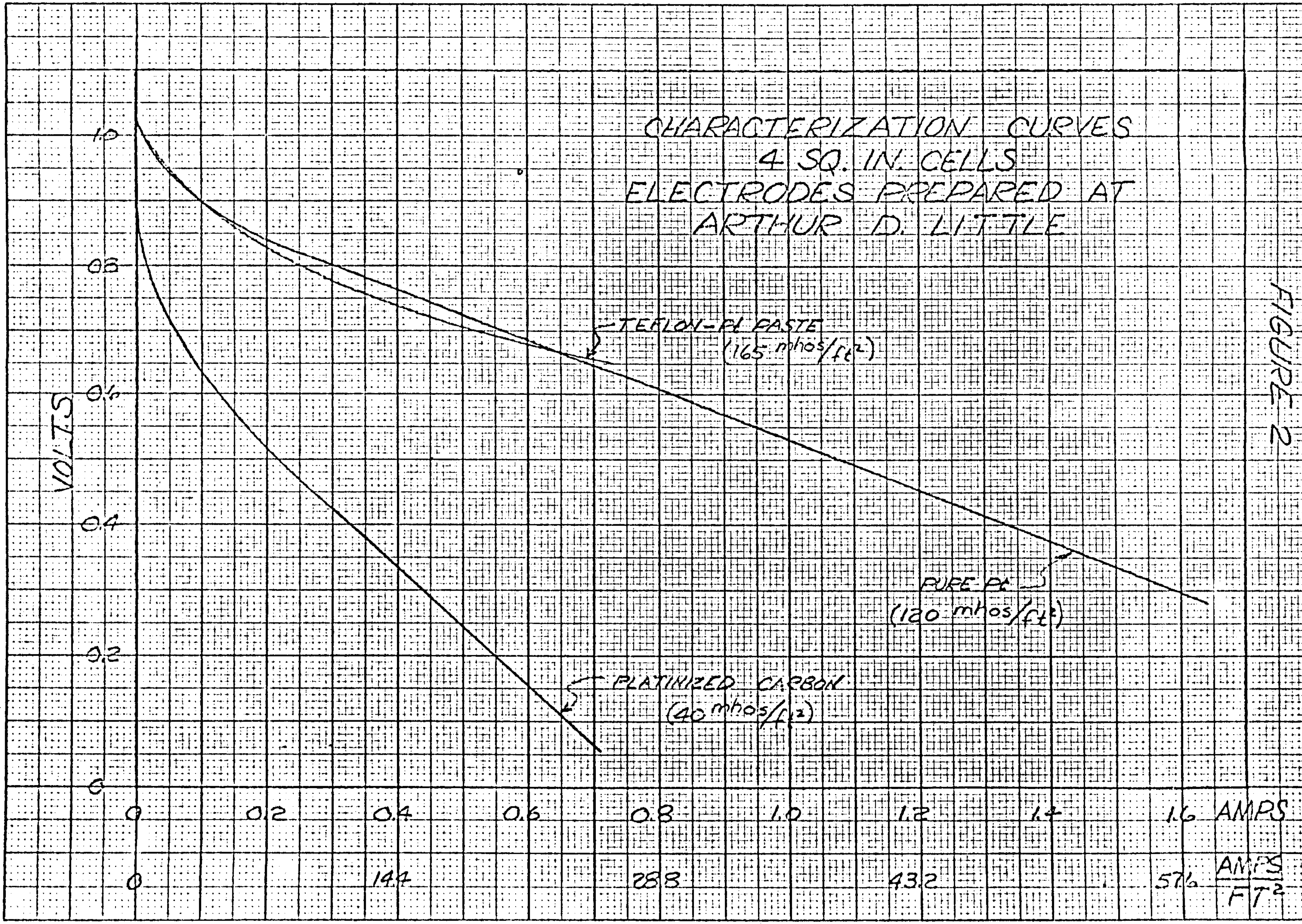


FIGURE 2

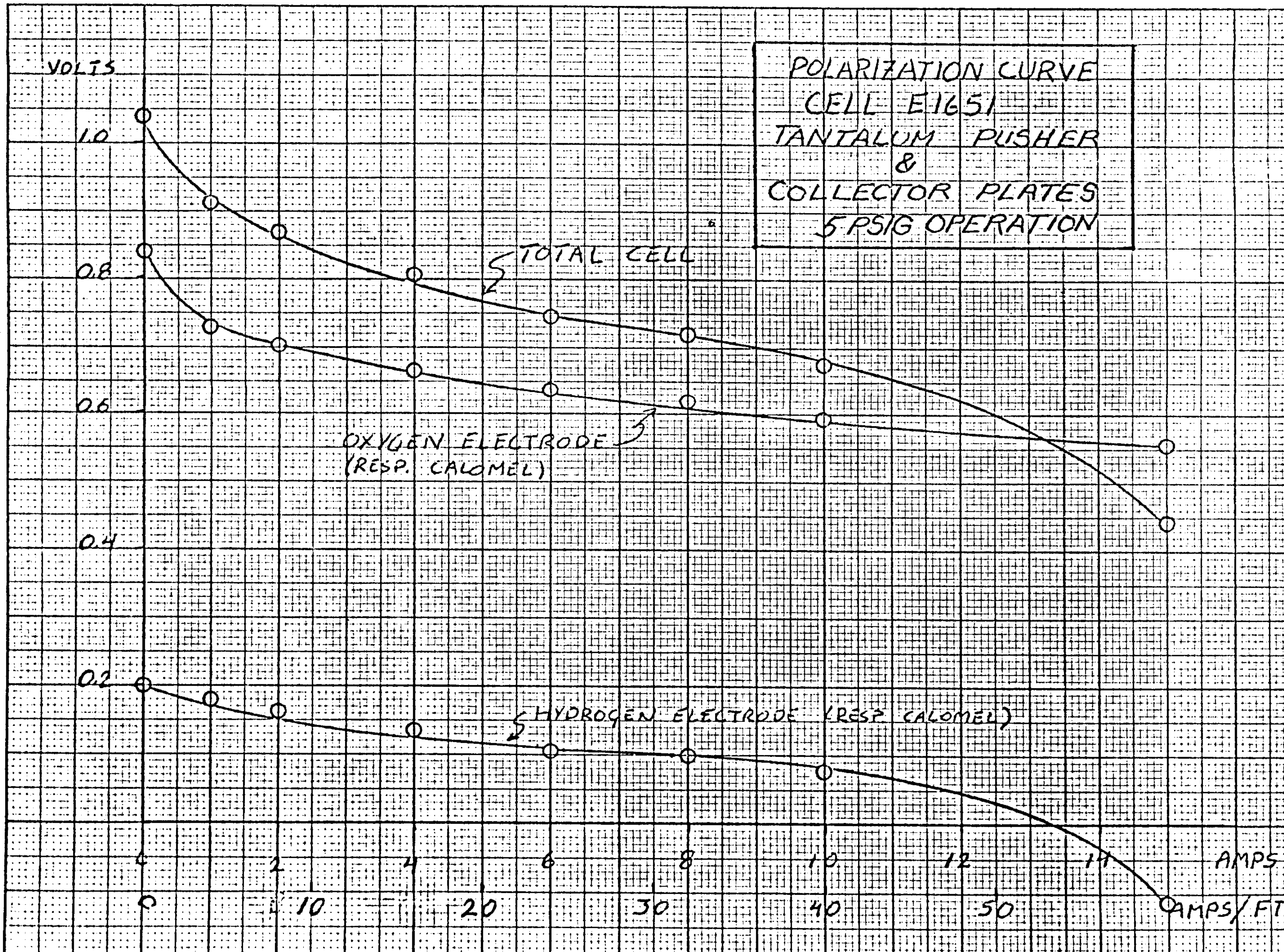

POLARIZATION CURVE
CELL E1651
TANTALUM PUSHER
&
COLLECTOR PLATES
5 PSIG OPERATION
VOLTS
1.0
0.8
0.6
0.4
0.2
TOTAL CELL
OXYGEN ELECTRODE
(RESP. CALOMEL)
HYDROGEN ELECTRODE (RESP. CALOMEL)
0
2
4
6
8
10
12
14
AMPS
0
10
20
30
40
50
AMPS/FT²

FIGURE 3

TABLE 2

Single 36 Sq. In. Cell Tests

Cell No.	Cell Components	Temp. °C.	Press. PSIG	Amps	Average Voltage	Time Hours	Spec. Cond. M /Ft.^{2}	REMARKS
E1279	Sintered	60	16	4.0	0.548	4		*Cell restarted after being shut down 140 hours due to malfunction in control system.
	Kel-F				0.602	24		**Recorded after cell had been off test 144 hours and restarted.
	Electrode				0.602	48	84	Test discontinued due to poor performance after restarting.
					*0.712	66		
	Std. Memb.				**0.570	87		
E1282	Paste	60	5	4.0	0.772	5		*Recorded after cell had been shut off 72 hours and restarted.
	Electrode				0.782	24	145	Cell test discontinued due to blockage of H_2 outlet channel.
					0.762	46		
	Std. Memb.				0.755	72		
					0.755	96		
					0.740	120	123	
					*0.780	123		
					0.780	144		
					0.758	216	109	
					0.744	240		
					0.728	264	109	
					0.748	288		
					0.700	312	79	
					-	384		
E1292	Sintered	30	16	4.0	0.762	4	121	Cell discontinued following 100 hours of operation. Except for accumulations of liquid in gas compartments, no changes were noted as a result of operation.
	Kel-F				0.780	24		
	Electrode				0.702	48	125	
					0.598	72		
	Std. Memb.				0.638	144	65	

TABLE 2 (Cont'd)

Single 36 Sq. In. Cell Tests

Cell No.	Cell Components	Temp. °C.	Press. PSIG	Amps	Average Voltage	Time Hours	Spec. Cond. Mhos/Ft.^{2}	REMARKS
E1651	Sintered	60	5	4.0	0.812	4	266	Still Running
	(Teflon)				0.802	24		
	Electrode				0.848	48		
					0.847	72	178	
	Std. Memb.				0.826	96		
					0.808	168		
					0.808	192	182	
	Tantalum				0.782	240		
	Pusher				0.768	288		
	of				0.813	336		
	Collector				0.791	360	132	
	Plates				0.785	384		
					0.812	408		
					0.813	432		
					0.782	504	121	
E1652	Sintered	60	1	4.0	0.648	8		*Cell is run only during day.
	(Teflon)			2.0	0.382	10		Still running
	Electrode				0.288	20		
				4.0	0.578	28		
	Std. Memb.				0.538	46		
					0.692	64		
					0.632	70		
	Externally				0.768	76		
	Fed PVC				0.738	84		
	Electrolyte				0.607	92		
	Compartment				0.728	100		
					0.738	108		

TABLE 2 (CONT'D)

Single 36 Sq. In. Cell Tests

Cell No.	Cell Components	Temp. °C.	Press. PSIG	Amps	Average Voltage	Time Hours	Spec. Cond. Mhos/Ft.^{2}	REMARKS
D9228	Sintered	Room	5	4.0	0.783	2	158	Still Running
	(Teflon)	Temp.			0.716	48		
	Electrode				0.742	72		
					0.772	96		
	Std. Memb.				0.746	120	129	
					0.738	144		
					0.756	168		
	Tantalum				0.728	192	98	
	Pusher and				0.725	216		
	Collector Plates				0.728	264	102	

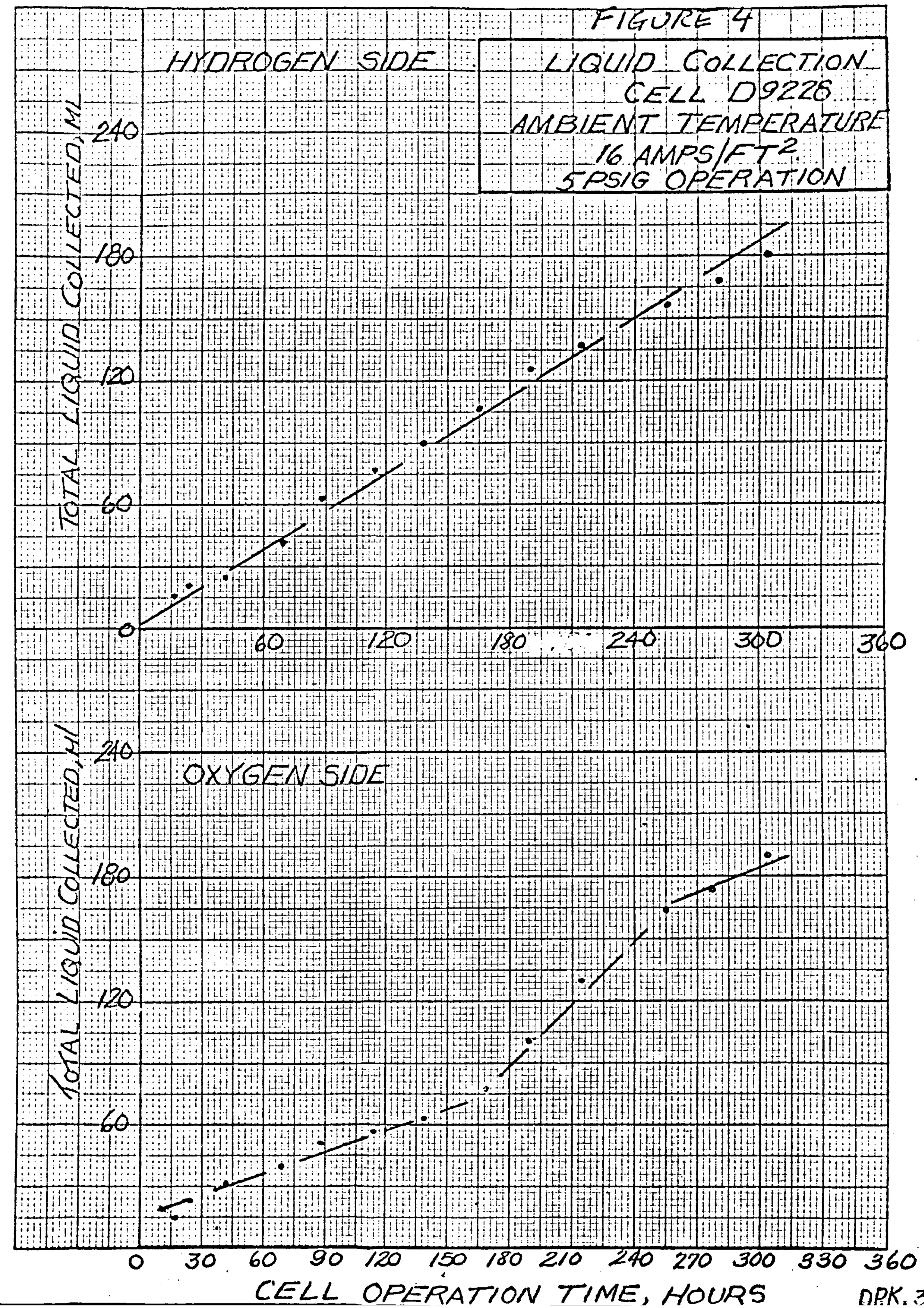


FIGURE 4
HYDROGEN SIDE
LIQUID COLLECTION
CELL D9226
AMBIENT TEMPERATURE
16 AMPS/FT²
5 PSIG OPERATION
TOTAL LIQUID COLLECTED, ML
0
60
120
180
240
360
OXYGEN SIDE
TOTAL LIQUID COLLECTED, Ml
0 30 60 90 120 150 180 210 240 270 300 330 360
CELL OPERATION TIME, HOURS
DRK.3

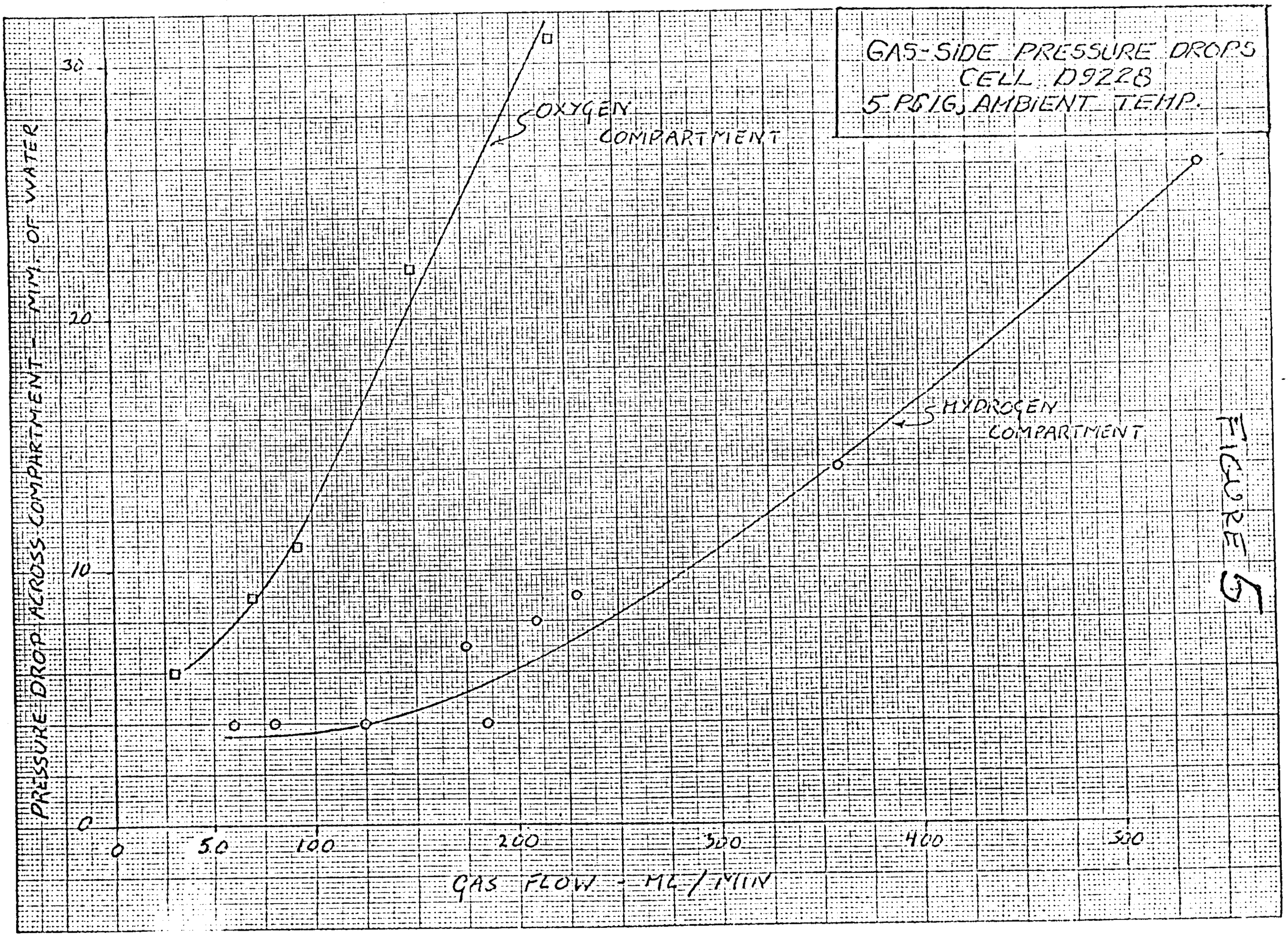
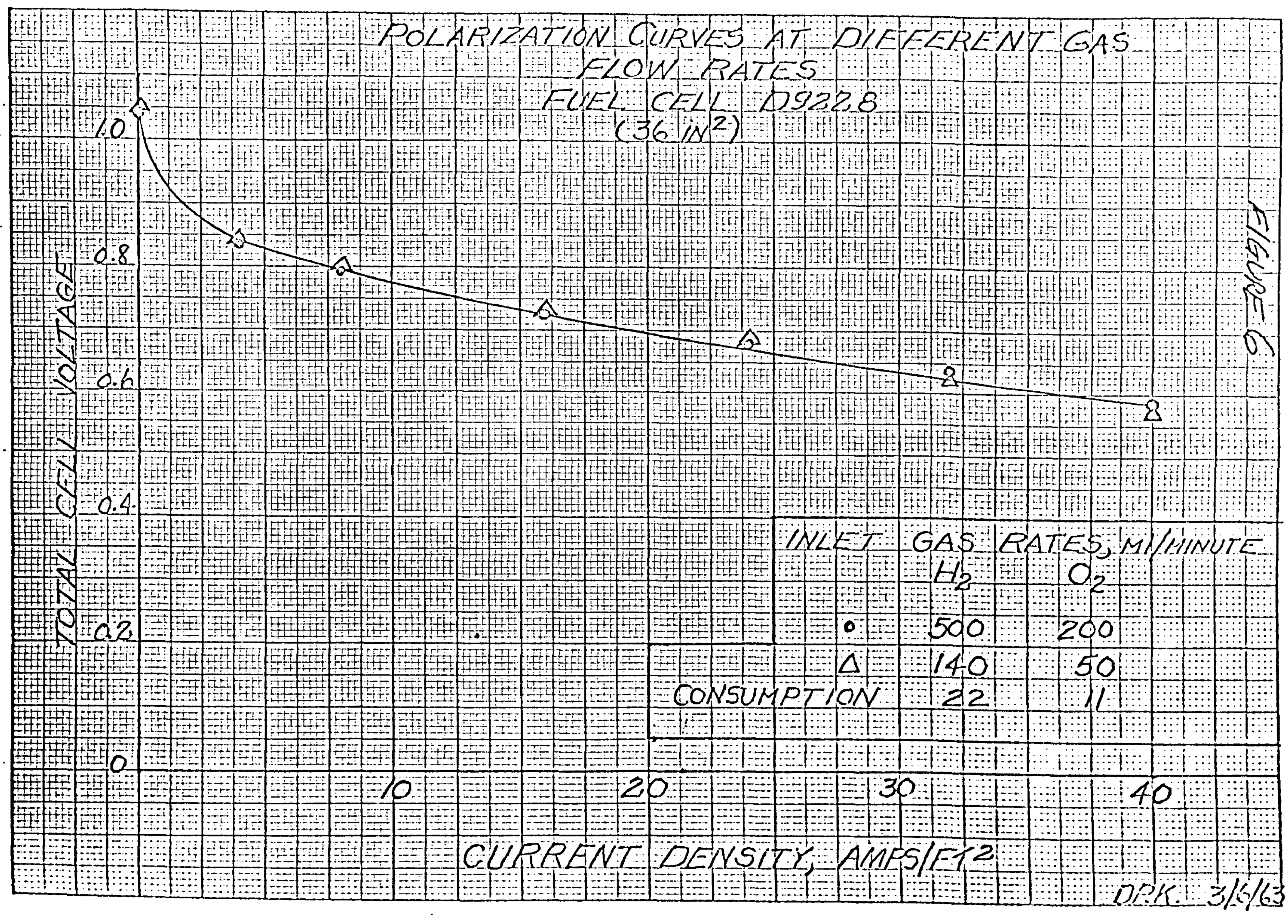

GAS-SIDE PRESSURE DROPS
CELL D9228
5 PSIG, AMBIENT TEMP.
OXYGEN COMPARTMENT
HYDROGEN COMPARTMENT
PRESSURE DROP ACROSS COMPARTMENT - MM. OF WATER
GAS FLOW - ML/MIN
0
10
20
30
0
50
100
200
300
400
500

FIGURE 5



POLARIZATION CURVES AT DIFFERENT GAS FLOW RATES
FUEL CELL D922.8
(36 IN^2)
FIGURE 6
TOTAL CELL VOLTAGE
1.0
0.8
0.6
0.4
0.2
0
10
20
30
40
CURRENT DENSITY, AMPS/FT^2
INLET GAS RATES, MI/MINUTE
H_2
O_2
500
200
140
50
CONSUMPTION
22
11
DPK. 3/5/63

TABLE 3

Status of Components for 5-Cell Batteries

COMPONENT	QTY	MATERIAL	ORDERED	RECEIVED	DELIVERY DATE	FABRICATION SENT	FABRICATION REC'D	OK FOR ASSEMBLY
End Plates	6	Stainless Steel	Yes	Yes		Yes	Yes	Yes
Tie Bolts	36	Stainless Steel	Yes	Yes		Yes	Yes	Yes
Nuts & Washers	72	Stainless Steel	Yes	Yes		Yes	Yes	Yes
Springs	36	Stainless Steel	Yes	Yes		Yes	Yes	Yes
Gas Compartments	20	Penton	Yes	No	15 March	No	No	
	20	Halon	Yes	No	15 March	No	No	
Electrolyte Compartments	10	Penton	Yes	No	15 March	No	No	
	10	Halon	Yes	No	15 March	No	No	
Gaskets	90	on-Dacron	Yes	Yes		Yes	Yes	Yes
	60	Buna N	Yes	Yes		No	No	
Insulators	6	Butyl Rubber	Yes	Yes		Yes	Yes	Yes
Pusher Plates	20	0.010" Tantalum	Yes	No	11 March	No	No	
	4	0.010" Niobium	Yes	Yes		4 March	No	
	8	Zirconium	Yes	Yes		4 March	No	
Separator Plates	20	Tantalum	Yes	No	11 March	No	No	
	4	Niobium	Yes	Yes		4 March	No	
	8	Zirconium	Yes	Yes		4 March	No	
Electrodes								
Gauze	30	80 Mesh Platinum	Yes	Yes		No	No	
Catalyst	630	Platinum Black	Yes	Yes		No	No	
Membranes	20	61 AZG	Yes	No	14 March	No	No	
	20	61 AZL	Yes	No	14 March	No	No	

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Thompson Ramo Wooldridge Inc.

TIME	T1 H2SO4 IN °F	T2 H2SO4 OUT °F	VACUUM PRESS. IN HG	CIR H2O °F	VAC LINE °F VAC. MANIFOLD	T3 °F / T4 °F	FLOW	H2O CONDENSED CC	PH
1230	START	TO SET	CONDITIONS						
1330	PURGE								
1342	PURGE	FROM	30.0 TO	34.9	SLIGHT	NOT CONDENSATE		ON CONDENSER	
1345	132.0	127.0	34.2	80.0	190/164	118/120	3.0	0	
1357	PURGE	FROM	30.5 TO	34.0					
1400	127.5	126.0	34.0	80.0	190/170	118/120	3.0	.4	1
1412	PURGE	FROM	30.7 TO	34.8					
1415	124.0	123.0	34.3	80.5	190/174	116/117	3.0	.3	1
1427	PURGE	FROM	30.7 TO	34.6					
1442	PURGE	FROM	31.0 TO	34.0					
1445	127.5	125.5	33.7	80.0	193/179	118/119	3.0	.5	1
1450	CHANGE	CONDITIONS	BY	INCREASING	TEMP.				
1512	PURGE	FROM	28.5 TO	33.5					
1515	131.0	129.0	33.4	87.5	194/182	120/121	3.0		
1527	PURGE	FROM	29.5 TO	33.5					
1530	141.5	138.5	33.0	98.5	193	128/127	3.0		
1542	PURGE	FROM	29.5 TO	34.0					
1545	141.0	140.0	32.8	100.5	192/182	131/132	3.0	.5	1
1557	PURGE	FROM	29.7 TO	34.5					
1600	139.5	137.5	33.0	100.5	192/182	130/131	3.0		
[illegible]	PURGE	FROM	30.1 TO	34.5					
1615	140.5	139.0	33.0	[illegible]	[illegible]/182	130/131	3.0		
1627	PURGE	FROM	[illegible] TO	33.5					
1630	142.0	140.5	33.2	100.0	192/181	132/132	3.0	.6	1
	STOP								

TITLE PERFORMANCE TEST #30
BAROMETER READING 29.19 IN HG @ 74 °F

MH 3148 IONAC MEMBRANE #18

FLUID [illegible]

ENGR. TH
JK
DATE 3-6-62
TEST NO. [illegible]
PROJECT [illegible]

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Thompson Ramo Wooldridge Inc.

TIME	T1 [illegible]	T2 [illegible]	VACUUM [illegible]	[illegible]	VAC [illegible]	T2 [illegible]	FLOW	[illegible]	[illegible]
0920	START	TEST	[illegible]	[illegible]					
1017	PURGE	FROM	[illegible] TO	34.5					
[illegible]	155.0	146.0	33.5	77.0	190/142	12?/120	3.0	.7	4
1032	PURGE	FROM	3? TO	34.1					
1040	172.0	166.0	32.7	82.0	190/152	146/150	3.0	10.7	5
1052	PURGE	FROM	[illegible] TO	34.5					
1055	174.0	168.5	33.5	81.0	[illegible]/162	153/15?	3.0		
☆ 1112	PURGE	FROM	[illegible] TO	34.5					
1115	178.5	173.0	33.?	80.0	192/175	15?/159	3.0	56.0	5
1127	PURGE	FROM	33.7 TO	34.5					
1130	177.0	173.0	33.6	80.0	19?/170	15?/160	3.0		
	[illegible]	[illegible]	[illegible] ADDED	TO	H_2SO_4				
1142	PURGE	FROM	33.8 TO	34.5					
1145	178.5	172.0	34.0	8?.0	19?/188	15?/16?	3.0		
1157	PURGE	FROM	29.0 TO	34.7					
12??	178.5	173.5	34.1	[illegible]	[illegible]/192	158/162	3.0		
1212	PURGE	FROM	[illegible] TO	34.8					
1215	17?.0	173.0	34.2	80.0	192/196	158/162	3.0		
	CHANGE	[illegible]	[illegible]					56.0	5
1227	[illegible]	[illegible]	[illegible] TO	34.8					
[illegible]	[illegible]	[illegible]	34.5	[illegible]	19?/1??	16?/[illegible]	3.0		
	[illegible]	[illegible]	[illegible]	[illegible]					
1242	PURGE	FROM	28.0 TO	34.6					
1245	174.5	174.5	34.5	[illegible]	[illegible]	160/163	3.0		
1257	PURGE	FROM	28.5 TO	34.8					
1300	17?.?	174.5	34.5	80.0	19?/[illegible]	16?/16?	3.0		
1312	PURGE	FROM	[illegible] TO	34.5					
1315	17?.5	173.5	34.5	[illegible]	[illegible]	16?/[illegible]	3.0	56.0	5
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	TEST #21			
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
				5.10 [illegible]	[illegible]	[illegible]	[illegible]	4.?	

TITLE [illegible] #21

[illegible] 29.42 IN HG 270°F

[illegible] MICROFRAME # 16

ELEC. TEMP. 175°F [illegible] 34 [illegible]

FLUID H_2SO_4 [illegible]

ENGR. [illegible]

DATE 2-11-63

TEST NO. [illegible]

PROJECT [illegible]

Thompson Ramo Wooldridge Inc.

TIME	T1 H_2SO_4 IN °F	T2 H_2SO_4 OUT °F	VACUUM PRESS CM HG	T? H_2O °F	VAC. LINE VAP °F / COND °F	T3 °F / T4 °F	FLOW	H_2O CONDENSED CC	PH
1215	SETTING CONDITIONS – EXCHANGE SPRAY TEST # 31								
	ADD 50 CC DIST H_2O TO H_2SO_4								
1237	PURGE FROM 27.0 TO 34.5								
	ADD 25 CC DIST H_2O TO H_2SO_4								
# 1242	PURGE FROM 32.0 TO 35.0								
1245	204.0	195.0	34.5	80.0	200 / 205	174 / 178	3.0	31.0	5
1257	PURGE FROM 29.0 TO 35.0								
1400	205.0	198.5	34.5	80.0	204 / 212	180 / 184	3.0		
1412	PURGE FROM 29.0 TO 35.2								
1415	201.5	195.5	34.5	80.0	205 / 213	178 / 182	3.0		
1427	PURGE FROM 30.0 TO 35.2								
1430	202.0	195.0	34.5	80.0	205 / 214	178 / 182	3.0		
1442	PURGE FROM 30.5 TO 35.2								
1445	203.5	197.5	34.?	80.0	204 / 216	179 / 182	3.0		
	CHANGE CONDENSER						.	69.5	5
	ADD 50 CC DIST H_2O TO H_2SO_4								
1457	PURGE FROM 30.5 TO 35.2								
1500	201.5	195.0	34.8	80.0	206 / 217	179 / 182	3.0		
1512	PURGE FROM 30.8 TO 35.2								
1515	201.5	195.0	34.7	80.0	206 / 218	178 / 182	3.0		
1527	PURGE FROM 31.0 TO 35.2								
1530	203.0	196.5	34.5	80.0	206 / 220	179 / 183	3.0		
1542	PURGE FROM 31.5 TO 35.2								
1545	204.0	197.5	34.8	80.0	206 / 220	180 / 184	3.0		
	CONTINUE TO CONDITIONS FOR PER. TEST # 33							68.0	
	EXTRACTED	137.5 CC			LD PH - 5				
				SLIDE COMPARATOR		PH 4.5			

TITLE PERIODIC PURGE TEST # 32
BAROMETER READING 75.02 CM @ 71°F
2-60 CATION AMF MEMBRANE # 16
ELEC TEMP 200°F   VAP PRESS 34.8 CM HG
FLUID H_2SO_4 ...

ENGR. TH
JK
DATE 2-11-63
TEST NO. [illegible]
PROJECT [illegible]

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Thompson Ramo Wooldridge Inc.

TIME	T_1 H_2SO_4 IN °F	T_2 H_2SO_4 OUT °F	VACUM PRESS CM HG	CIR. H_2O °F	VAC LINE °F / VAC MAN °F	T_3 °F / T_4 °F	FLOW	H_2O CONDENSED CC	PH
1545	SETTING CONDITIONS - CONTINUING FROM TEST #32								
	ADD 75 CC DIST H_2O TO H_2SO_4								
[illegible]	PURGE	32.0	TO 36.0						
* 1612	PURGE	FROM	34.0 TO 36.4						
1615	204.0	198.0	36.0	40.0	205/220	181/185	3.0	33.0	5
	ADD	50 CC	DIST H_2O TO	H_2SO_4					
1627	PURGE	FROM	32.0 TO	36.0					
1630	202.5	196.5	36.2	40.0	205/220	181/185	3.0		
1642	PURGE	FROM	32.5	TO 36.5					
1645	203.5	197.0	36.2	40.0	206/222	181/185	3.0		
1657	PURGE	FROM	32.5	TO 36.5					
1700	204.0	197.5	36.2	40.0	206/222	182/[illegible]	3.0		
	ADD 50 CC DIST H_2O TO H_2SO_4								
1712	PURGE	FROM	34.0 TO	36.5					
1715	203.0	197.0	36.2	40.0	206/224	181/185	3.0	66.0	5
	CHANGE COLLECTOR								
1727	PURGE	FROM	32.8 TO	36.5					
1730	203.0	197.0	36.2	40.0	[illegible]/224	181/185	3.0		
1742	PURGE	FROM	33.2 TO	36.5					
1745	203.0	197.0	36.2	40.0	216/224	181/185	3.0		
	ADD 50 CC DIST H_2O TO H_2SO_4								
1757	PURGE	FROM	32.6 TO	36.5					
1800	202.0	196.0	36.2	40.0	206/224	180/185	3.0		
1812	PURGE	FROM	32.6 TO	36.5					
1815	202.0	196.0	36.2	40.0	206/224	180/185	3.0	67.0	
	STOP								
	EXTRACTED		133.0	[illegible]	[illegible]				
				SAFE	[illegible]		PH 6.6		

TITLE PERFORMANCE TEST # 33	ENGR. TH
BAROMETER READING 74.72 CM HG @ 71°F	JK
	DATE 2-11-63
C-63 CATION [illegible] MEMBRANE #16	TEST NO. [illegible]
	PROJECT [illegible]
ELEC TEMP. 200°F VAC PRESS 36.2 CM HG	
FLUID H_2SO_4 [illegible]	

TPFC-557

Thompson Ramo Wooldridge Inc.

TIME	T1 H2SO4 IN °F	T2 H2SO4 OUT °F	VACUUM PRESS CM HG	CIR H2O °F	VAC LINE °F / VAC MAN °F	T3 °F / T4 °F	FLOW	H2O COLLECTED CC	PH
0830	START	TO SET	CONDITIONS						
0933	PURGE	FROM	32.0 TO	35.8					
0935	155.0	139.0	35.2	40.0	194/154	122/125	3.0	2.0	5
0942	PURGE	FROM	32.0 TO	36.0					
0945	154.0	147.0	35.3	38.0	192/162	124/127	3.0	9.0	5
* 0957	PURGE	FROM	32.5 TO	36.0					
1000	153.0	149.0	35.4	38.0	192/170	137/140	3.0	10.0	5
1012	PURGE	FROM	32.0 TO	36.2					
1015	151.0	147.5	35.5	38.0	191/178	137/140	3.0		
1027	PURGE	FROM	31.6 TO	36.0					
1030	151.5	148.0	35.5	38.0	191/184	139/137	3.0		
1042	PURGE	FROM	32.0 TO	36.1					
1045	152.0	148.5	35.5	38.0	191/190	137/140	3.0		
1057	PURGE	FROM	32.0 TO	36.1					
1100	152.5	149.0	35.5	38.0	191/193	138/141	3.0		
1112	PURGE	FROM	32.0 TO	36.0					
1115	153.0	150.0	35.4	38.0	191/196	139/142	3.0		
	HG WENT UP	1CM THEN	DOWN - ROCKED	VACUUM					
	THEN	SETTLED OUT	NO [illegible]						
1127	PURGE	FROM	32.1 TO	35.9					
1130	153.5	150.0	35.4	38.0	191/200	140/143	3.0		
	ADD	50 CC	DIST. H2O	TO H2SO4					
1142	PURGE	FROM	31.5 TO	36.1					
1145	150.0	149.0	35.5	38.0	190/202	137/142	3.0		
1157	PURGE	FROM	31.9 TO	36.1					
1200	150.0	149.0	35.5	38.0	190/204	132/142	3.0		
	CONTINUE	TO SET	CONDITIONS	FOR PT.	#35				
	EXTRACTED		77.5 CC		PH 5				
				SLIDE	COMPARATOR		PH 4.5		

TITLE PERFORMANCE TEST #34

BAROMETER READING 74.63 CM HG @ 71°F

[illegible] MEMBRANE #16

FEED TEMP. 150°F VAP PRESS. 35.5 CM HG

FLUID H2SO4 CONC 80%

ENGR. TH

DATE [illegible]

TEST NO. [illegible]

PROJECT [illegible]

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Thompson Ramo Wooldridge Inc.

TIME	T1 H2SO4 °F	T2 H2SO4 °F	VACUM PRESS CM. HG	C/W H2O °F	VAP LINE °F / VAP MAN °F	T3 °F / T4 °F	FLOW	H2O CONDENSED CC	PH
1200	SETTING CONDITIONS - CONTINUING FROM TEST #4								
* 1242	PURGE	FROM	32.5 TO	35.8					
1245	176.0	171.0	35.1	38.0	190/205	157/160	3.0	37.0	5
1257	PURGE	FROM	32.0 TO	35.9					
1300	177.0	171.5	35.6	38.0	190/206	157/160	3.0		
1312	PURGE	FROM	31.5 TO	35.9					
1315	177.0	172.0	35.6	38.0	190/206	157/160	3.0		
	ADD	50CC	DIST H2O	TO H2SO4					
1327	PURGE	FROM	31.5 TO	35.9					
1330	178.0	172.0	35.7	38.0	190/207	158/161	3.0		
1342	PURGE	FROM	31.0 TO	35.9					
1345	179.0	174.0	35.7	38.0	190/207	160/163	3.0	58.0	5
	CHANGE	COLLECTOR							
1357	PURGE	FROM	31.0 TO	35.9					
1400	179.0	174.0	35.7	38.0	192/208	160/164	3.0		
1412	PURGE	FROM	31.5 TO	35.9					
1415	179.0	174.0	35.7	38.0	192/210	160/164	3.0		
	ADD 50	CC	DIST H2O	TO H2SO4					
1427	PURGE	FROM	31.5 TO	35.9					
1430	177.5	173.0	35.7	38.0	194/212	159/163	3.0		
1442	PURGE	FROM	31.5 TO	35.9					
1445	177.5	173.0	35.7	38.0	196/212	159/163	3.0	58.0	5
	STOP								
	EXTRACTED		1160 CC	PH 5					
					SLIDE	[illegible]		PH 4.7	

TITLE PERFORMANCE TEST #5 — ENGR. [illegible]

BAROMETER READING 74.50 CM HG @ 72°F — [illegible]

DATE 2-[illegible]-63

C-60 CATION BASE MEMBRANE #16 — TEST NO. [illegible]

PROJECT [illegible]

ELEC TEMP 175°F — VAP PRESS 35.7 CM HG

FLUID [illegible] 50%

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Thompson Ramo Wooldridge Inc.

TIME	T1 H_2SO_4 [illegible]	T2 H_2SO_4 OUT °F	VACUUM [illegible] CM Hg	[illegible] H_2O %	VAC LINE / VAC [illegible]	[illegible]	FLOW	H_2O COLLECTED [illegible]	[illegible]
0930	START	TO SET	CONDITIONS						
1022	PURGE	FROM	31.5 TO	33.1					
1045	153.0	137.0	33.0	78.0	190/210	119/126	2.6	20	5
1057	PURGE	FROM	29.0 TO	34.0					
1100	190.0	176.0	33.2	80.0	200/214	153/160	2.6	29.0	5
1112	PURGE	FROM	29.0 TO	34.2					
1115	193.0	182.0	33.5	80.0	205/216	161/167	2.8	26.0	5
1127	PURGE	FROM	29.0 TO	34.2					
	ADD	75 CC	DIST H_2O	TO H_2SO_4					
1142	PURGE	FROM	30.0 TO	34.3					
1145	205	188.0	33.7	80.0	208/220	170/180	2.8	57.0	5
	ADD	30 CC	DIST	H_2O TO H_2SO_4					
[illegible]	PURGE	FROM	29.0 TO	34.2					
1200	200.0	190.0	33.5	80.0	208/220	167/177	2.8		
1212	PURGE	FROM	29.5 TO	34.2					
1215	201.0	192.0	33.6	80.0	208/221	172/178	2.8		
	CHANGE	COLLECTOR						64.5	5
	ADD	50 CC	DIST	H_2O TO H_2SO_4					
1227	PURGE	FROM	29.3 TO	34.4					
1230	202.0	190.5	33.7	80.0	207/222	171/176	2.8		
	ADD	25 CC	DIST H_2O	TO H_2SO_4					
1242	PURGE	FROM	31.6 TO	34.4					
1245	202.0	193.0	33.7	80.0	207/222	174/181	2.9		
	CHANGE	COLLECTOR						61.0	5
	ADD 25.0	CC	DIST	H_2O TO H_2SO_4					
1257	PURGE	FROM	29.3 TO	34.4					
1300	206.0	196.0	33.7	80.0	206/[illegible]	175/182	2.8		
	ADD	25.0 CC	DIST H_2O	TO H_2SO_4					
1312	PURGE	FROM	29.5 TO	34.3					
1315	204.5	196.0	33.7	80.0	[illegible]	175/183	2.8		
	CHANGE	COLLECTOR						62.5	5

TITLE PERFORMANCE TEST # 26
BAROMETER READING 74.02 CM Hg @ 72°F

C-100 [illegible] AMF MEMBRANE #18

[illegible] TEMP [illegible] °F [illegible] 33.7 CM Hg

FLUID H_2SO_4 CONC 70%

ENGR. TH
J.C.
DATE 2-14-6[illegible]
TEST NO. [illegible]
PROJECT [illegible]
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Thompson Ramo Wooldridge Inc.

TIME	T_1 H_2SO_4 in °F	T_2 H_2SO_4 out °F	VACUUM PRESS. cm Hg	CIR. H_2O °F	[illegible] °F	T_3 °F / T_4 °F	FLOW	H_2O [illegible] CC	PH
	ADD 50 CC.	OUT [illegible]			[illegible] .04				
1327	PURGE	FROM	29.9	TO 34.3					
1330	200.0	192.0	33.7	80.0	207 / [illegible]	174 / 180	2.8		
	ADD 250 [illegible]	OUT [illegible]			[illegible] .04				
1342	PURGE	FROM	30.5 TO	34.3					
1345	205.0	195.0	33.7	80.0	208 / 224	175 / 182	2.8	560	5
	CONTINUE TO		SET CONDITIONS		FOR REP. TEST #37				
	TOTAL	EXTRACTED		244.0 CC	[illegible]				

SEE SUMMARY [illegible]

TITLE PERFORMANCE TEST # 36

BAROMETER READING 74.02 CM Hg @ 72°F

C-60 CATION [illegible] MEMBRANE #16

ELEC TEMP [illegible]°F VAP PRESS 33.7 CM Hg

FLUID H_2SO_4 [illegible]%

ENGR. [illegible]

DATE 2-14-[illegible]

TEST NO. [illegible]

PROJECT [illegible]

PAGE 2 [illegible]

TPFC-557

Thompson Ramo Wooldridge Inc.

TIME	T_1 H_2SO_4 IN °F	T_2 H_2SO_4 OUT °F	VACUUM [illegible] cm Hg	CIR H_2O °F	VA [illegible]	T_3 °F T_4 °F	[illegible]	H_2O COLLECTED cc	[illegible]
1345	SETTING CONDITIONS CONTINUE FROM TEST #24								
	ADD 25.0 CC DIST H_2O TO H_2SO_4								
1412	PURGE FROM [illegible] TO 32.0								
1415	200.0	191.5	32.0	108.0	207 / 212	174 / 182	2.8	64.0	5
	ADD 50 CC DIST H_2O TO H_2SO_4								
1427	PURGE FROM 25.0 TO 31.0								
1428	STOP - CONDENSER [illegible]							25.0	
	REPLACE CONDENSER								
1600	START SETTING CONDITIONS							25.0	5
	STOP VACUUM LEAK								

TITLE [illegible] PERFORMANCE TEST #37 | ENGR. [illegible]
[illegible] | DATE [illegible]
[illegible] MEMBRANE [illegible] | TEST NO. [illegible]
| PROJECT [illegible]
[illegible]
FLUID [illegible] CONC [illegible]

TPFC-557

Thompson Ramo Wooldridge Inc.

TIME	T_1 H_2SO_4 IN °F	T_2 H_2SO_4 OUT °F	VACUUM PRESS IN HG	CIR. H_2O °F	VAP TEMP °F / VAP [illegible]	T_3 °F / T_4 °F	FLOW	H_2O CONDENSED CC	PH
1122	SETTING	CONDITIONS							
1227	PURGE	FROM	22.0 TO	23.5					
1230	158.0	141.0	23.5	96.0	208/176	128/127	2.8	6.0	5
1242	PURGE	FROM	29.0 TO	31.0					
1245	190.5	174.0	30.2	106.0	208/180	164/158	2.8	16.0	1
	ADD	25 CC	DIST. H_2O	TO H_2SO_4					
1257	PURGE	FROM	24.5 TO	25.8					
1300	205.0	193.0	24.8	120.0	208/188	167/176	2.8	30.0	2
1312	PURGE	FROM	25.5 TO	2[illegible]					
1315	191.0	18[illegible]	26.3	121.0	208/190	16[illegible]/[illegible]	2.8	34.0	5
* 1327	PURGE	FROM	25.6 TO	28.5					
1330	199.5	187.0	27.8	118.0	208/192	167/172	2.8	30.0	5
	ADD	50.0 CC	DIST H_2O	TO H_2SO_4					
1342	PURGE	FROM	25.0 TO	27.5					
1345	203.5	193.0	26.8	120.0	209/194	173/172	2.8		
	ADD	20 CC	DIST	H_2O TO	H_2SO_4				
1357	PURGE	FROM	25.4 TO	27.4					
1400	204.0	193.0	26.8	120.0	2[illegible]/198	174/179	2.8		
	ADD	[illegible] CC	DIST H_2O	TO H_2SO_4					
	CHANGE	COLLECTOR						20.0	5
	ADD	75.0 CC	DIST	H_2O TO	H_2SO_4				
1412	PURGE	FROM	25.5 TO	27.4					
1415	203.5	193.5	26.8	120.0	210/200	17[illegible]/1[illegible]	2.8		
1427	PURGE	FROM	25.3 TO	27.4					
1430	203.5	194.0	26.9	120.0	210/200	176/181	2.8		
	ADD	100 CC	DIST	H_2O TO	H_2SO_4				
	CHANGE	COLLECTOR						62.0	5
1442	PURGE	FROM	25.5 TO	27.5					
1445	203.5	194.0	26.9	120.0	210/201	176/181	2.8		
	ADD	25.0 CC	DIST	H_2O TO	H_2SO_4				
					SLIDE	COMPARATOR		PH 0.3	

TITLE PERFORMANCE TEST #3	ENGR. [illegible]
BAROMETER [illegible] 75.65 CM HG @ 72°F	[illegible]
	DATE [illegible]
C-60 [illegible]	TEST NO. [illegible]
	PROJECT 512 [illegible]
FEED TEMP 200°F [illegible] 26.9 IN HG	
FLUID H_2SO_4 [illegible]	PAGE 1 OF 2

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Thompson Ramo Wooldridge Inc.

TIME	#1 H_2SO_4 [illegible] °F	#2 H_2SO_4 OUT °F	VACUUM PRESS. CM HG	CIR H_2O °F	VAC LINE VAC °F / [illegible]	T_3 T_4 °F	FLOW	H_2O CONDENSED CC	pH
1457	PURGE	FROM	25.5 TO	27.5					
1500	205.0	194.0	26.9	[illegible]	210/202	178/181	2.8		
	ADD [illegible] CC [illegible]				[illegible]				
	CHANGE COLLECTOR							68.0	5
1512	PURGE	FROM	25.5 TO	27.5					
1515	202.5	193.5	27.0	122.0	210/203	179/181	2.8		
	ADD 35.0 CC		[illegible]		H_2SO_4				
	ADD 25.0 CC		[illegible]		[illegible]				
1527	PURGE	FROM	25.5 TO	27.5					
1530	206.0	196.0	27.0	120.0	210/204	179/182	2.2	[illegible]	
	CONTINUE TO SET CONDITIONS FOR TEST #39								
	EXTRACTED		273.0 CC		[illegible]				
			SLIDE	COMPARATOR	pH 4.3				

TITLE PERFORMANCE TEST #38

BAROMETER READING 75.65 CM HG @ 72°F

C-60 [illegible] AMF MEMBRANE #2

[illegible] TEMP. [illegible] °F VAP. PRESS 26.9 CM HG

FLUID H_2SO_4 CONC 20%

ENGR. TH

JK

DATE 2-15-62

TEST NO. [illegible]

PROJECT 512-[illegible]

PAGE 2 OF 2

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Thompson Ramo Wooldridge Inc.

TIME	T_1 H_2SO_4 IN °F	T_2 H_2SO_4 OUT °F	VACUUM PRESS. CM Hg	CIR H_2O °F	VAC LINE °F / VAC. MAIN °F	T_3 °F / T_4 °F	FLOW	H_2O CONDENSED CC	PH
1530	SETTING COND.		CONTINUE FROM TEST #38						
	ADD 50.0 CC		DIST H_2O TO H_2SO_4						
1542	PURGE	FROM	24.5 TO 26.5						
	ADD 50.0 CC		DIST H_2O TO H_2SO_4						
1557	PURGE	FROM	21.0 TO 23.0						
1600	205.0	194.5	22.1	140.0	210 / 206	179 / 182	2.8	69.5	5
	ADD 50.0 CC		DIST H_2O TO H_2SO_4						
1612	PURGE	FROM	21.0 TO 22.4						
1615	204.0	195.0	21.8	140.0	211 / 207	179 / 182	2.8		
1627	PURGE	FROM	21.3 TO 22.5						
1630	203.0	194.0	22.3	140.0	211 / 205	179 / 182	2.8		
	CHANGE COLLECTOR							74.5	5
1642	PURGE	FROM	21.6 TO 23.0						
1645	202.0	193.5	22.6	140.0	211 / 208	178 / 181	2.8		
	ADD 50.0 CC		DIST H_2O TO H_2SO_4						
1657	PURGE	FROM	21.5 TO 23.0						
1700	206.0	198.0	22.4	140.0	211 / 208	180 / 183	2.8		
	ADD	50.0 CC	DIST. H_2O TO H_2SO_4						
1712	PURGE	FROM	21.6 TO 23.0						
1715	201.0	193.5	22.5	140.0	211 209	179 182	2.8		
	CHANGE COLLECTOR							68.0	5
	ADD 25.0 CC		DIST H_2O TO H_2SO_4						
1727	PURGE	FROM	21.3 TO 23.0						
1730	205.0	195.5	22.2	140.0	211 / 209	180 / 183	2.8		
1742	PURGE	FROM	21.2 TO 23.0						
1745	205.0	196.0	22.3	140.0	211 / 210	181 / 183	2.8		
	ADD 50.0 CC		DIST H_2O TO H_2SO_4						
1757	PURGE	FROM	21.2 TO 23.0						
1800	[illegible]	197.5	22.2	140.0	211 / 210	181 / 183	2.8	91.5	
	CONTINUE TO		SET CONDITIONS		FOR TEST #40				
	EXTRACTED		224.0 CC		[illegible]		COMBINED		1.5

TITLE PERFORMANCE TEST #39

BAROMETER READING 7[illegible] CM HG @ 73°F

C-60 CATION AMF MEMBRANE #2

ELEC TEMP 200°F — VAC PRESS 22.3 CM Hg

FLUID H_2SO_4 CONC 20%

ENGR. [illegible]

DATE 2-15-[illegible]

TEST NO. [illegible]

PROJECT [illegible]

TPFC-557

Thompson Ramo Wooldridge Inc.

TIME	T_1 H_2SO_4 IN °F	T_2 H_2SO_4 OUT °F	VACUM PRESS. CM Hg	CIR H_2O °F	VAC LINE °F / VAC MAN	T_3 °F / T_4 °F	FLOW	H_2O CONDENSED CC	PH
1800	SETTING CONDITIONS CONTINUING FROM TEST #39								
	ADD 50.0 CC DIST. H_2O TO H_2SO_4								
1812	PURGE FROM 19.5 TO 21.5								
1825	PURGE FROM 16.0 TO 18.0								
1828	204.0	197.0	16.5	160.0	211/210	183/184	2.8	44.5	5
	ADD 50.0 CC DIST H_2O TO H_2SO_4								
1840	PURGE FROM 15.5 TO 17.0								
1843	205.0	197.0	16.4	160.0	211/211	184/184	2.8		
1855	PURGE FROM 15.7 TO 17.0								
1858	206.0	199.0	16.4	[illegible]	212/212	185/186	2.8		
	ADD 25.0 CC DIST H_2O TO H_2SO_4								
1910	PURGE FROM 15.9 TO 17.0								
1913	206.0	199.0	16.7	160.0	212/212	185/186	2.8		
1925	PURGE FROM 16.2 TO 17.2								
1928	206.0	198.5	16.8	160.0	212/212	184/186	2.8		
	CHANGE COLLECTOR							77.0	5
	ADD 50.0 CC DIST H_2O TO H_2SO_4								
1940	PURGE FROM 16.5 TO 17.5								
1943	203.5	197.0	17.2	160.0	212/212	182/184	2.8		
1955	PURGE FROM 16.4 TO 17.5								
1958	204.5	197.5	17.1	160.0	212/212	183/184	2.8		
	ADD 25.0 CC DIST H_2O TO H_2SO_4								
2010	PURGE FROM 16.5 TO 17.5								
2013	204.0	197.0	17.1	160.0	212/212	183/184	2.8		
2025	PURGE FROM 16.6 TO 17.7								
2028	204.0	197.0	17.3	159.5	212/212	183/184	2.8		
	STOP								
	EXTRACTED 159.0 CC 60.PHE								
				SLIDE COMPARATOR PH 4.5					

TITLE PERFORMANCE TEST #40
BAROMETER READING 75.90 CM Hg @ 74°F
[illegible] CATION SIDE MEMBRANE #[illegible]
ELEC TEMP 200°F VAC PRESS. 17.1 CM Hg
FLUID H_2SO_4 PURE 20%

ENGR. [illegible]
DATE 2-15-6[illegible]
TEST NO. [illegible]
PROJECT [illegible]

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Thompson Ramo Wooldridge Inc.

TIME	T_1 H_2SO_4 IN °F	T_2 H_2SO_4 OUT °F	VACUM PRESS CM Hg	CIR H_2O °F	VAC LINE °F / VAC MAN °F	T_3 °F / T_4 °F	FLOW	H_2O CONDENSED CC	[illegible]
0920	START	TO SET	CONDITIONS						
	STOP TO	[illegible]	[illegible] H_2SO_4		[illegible]	27.8	GR.		
1215	START	TO SET	CONDITIONS						
1212	PURGE ·	NO CH	ANGE						
1322	PURGE	FROM	34.3 TO	35.8					
1325	200.0	184.0	35.8	78.0	200 / 202	163 / 164	3.0	0	
1347	PURGE	FROM	[illegible] TO	[illegible]					
1350	200.0	197.0	35.8	[illegible]	208 / 214	[illegible] / 177	[illegible]	18	5
* 1357	PURGE	FROM	34.4 TO	36.0					
1400	201.0	194.0	35.7	80.0	20[illegible] / 204	176 / 177	3.0	1.1	5
1412	PURGE	FROM	33.5 TO	36.[illegible]					
1415	205.0	201.0	35.7	80.0	203 / 206	182 / 182	3.0		
1427	PURGE	FROM	34.3 TO	36.0					
1430	197.0	194.0	35.6	80.0	208 / [illegible]	179 / 180	3.0		
1442	PURGE	FROM	33.5 TO	35.9					
1445	206.0	197.0	35.8	80.0	209 / 208	18[illegible] / 182	3.0		
1457	PURGE	FROM	33.8 TO	35.9					
1500	206.0	192.0	35.8	80.0	210 / 208	184 / 184	3.0	4.7	5
1512	PURGE	FROM	TO						
1515									
	STOP								
	SOME TIME	BETWEEN	1500	& 1512	BLEW	Hg			
	THROUGH	STILL	& INTO	CONDENSER					
	EXTRACTED	4.7 CC	LOOPHS						

TITLE PERFORMANCE TEST # 41

BAROMETER READING 74.72 cm Hg @ 77°F

C-60 CATION MEMBRANE #16

ELEC TEMP

FLUID H_2SO_4 CONC 60%

ENGR. [illegible]

DATE 2-18-63

TEST NO. [illegible]

PROJECT [illegible]

TPFC-557

Thompson Ramo Wooldridge Inc.

TIME	T_1 H_2O in °F	T_2 H_2SO_4 out °F	VACUUM PRESS [illegible]	CIR H_2O °F	VAC LINE °F / VAC MAN °F	T_3 °F / T_4 °F	FLOW	H_2O CONDENSED	[illegible]
1315	SETTING	CONDITIONS							
1427	PURGE	FROM	35.0 TO	35.5					
1430	155.0	129.0	35.5	38.0	183/140	97/122	2.5	0	
1442	PURGE	FROM	34.5 TO	35.5					
1445	177.0	176.0	35.3	38.0	198/150	109/164	4.0	0	
1457	PURGE	FROM	33.5 TO	35.9					
1500	205.0	194.0	35.5	38.0	188/156	154/172	4.0	0	
* 1512	PURGE	FROM	33.5 TO	35.8					
1515	204.5	197.5	35.4	38.0	195/162	177/184	3.0	7.0	5
1527	PURGE	FROM	33.5 TO	35.6					
1530	203.5	195.0	35.5	38.0	197/170	178/182	3.0		
1542	PURGE	FROM	34.0 TO	35.7					
1545	205.0	200.0	35.6	38.0	202/174	180/184	3.0		
1557	PURGE	FROM	34.0 TO	35.8					
1600	206.0	200.0	35.6	38.0	202/178	182/186	3.0		
1612	PURGE	FROM	34.1 TO	36.0					
1615	198.5	196.0	35.7	38.0	203/180	182/182	3.0		
1627	PURGE	FROM	34.5 TO	36.0					
1630	206.0	199.5	35.8	38.0	203/182	182/185	3.0		
1642	PURGE	FROM	34.3 TO	36.0					
1645	204.5	201.5	35.9	38.0	204/186	185/190	3.0		
1657	PURGE	FROM	34.3 TO	36.0					
1700	201.0	195.0	35.6	38.0	204/188	182/184	3.0		
1712	PURGE	FROM	34.4 TO	36.0					
1715	206.0	202.0	35.8	38.0	204/192	184/186	3.0	5.5	5
	STOP								
	EXTRACTED		8.5 CC		[illegible] FULL				

TITLE PERFORMANCE TEST # 42 — ENGR. TH

GENERATOR [illegible] 7350 @ [illegible]°F — JK

DATE 3-15-[illegible]

[illegible] 3/16 — TEST NO. [illegible] *

PROJECT [illegible]

ELEC TEMP [illegible] 200°F — VAC PRESS 35.[illegible]

FLUID [illegible] 61%

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Thompson Ramo Wooldridge Inc.

TIME	T_1 H_2SO_4 [illegible]	T_2 H_2SO_4 OUT °F	VACUUM PRESS cm Hg	CIR. H_2O °F	VAC LINE °F / VAC MAN °F	T_3 °F / T_4 °F	FLOW	H_2O EXTRACTED [illegible]	PH
0915	SETTING	CONDITIONS							
1027	PURGE	FROM	33.0 TO	35.0					
1030	180.0	167.0	34.0	76.0	194 / 162	148 / 150	3.0	0	
1042	PURGE	FROM	32.0 TO	34.8					
1045	204.0	191.5	34.8	79.0	196 / 170	169 / 172	3.0	7.0	5
* 1057	PURGE	FROM	33.0 TO	35.0					
1100	204.0	199.0	34.8	80.0	201 / 176	182 / 184	3.0	7.5	5
1112	PURGE	FROM	32.5 TO	35.1					
1115	199.2	194.5	35.0	80.0	202 / 180	179 / 181	3.0		
1127	PURGE	FROM	33.1 TO	35.1					
1130	206.0	200	34.9	80.0	200 / 184	181 / 184	3.0		
1142	PURGE	FROM	33.1 TO	35.1					
1145	202.5	199.0	35.0	80.0	208 / 188	181 / 184	3.0		
1157	PURGE	FROM	33.1 TO	35.1					
1200	202.0	197.0	35.0	80.0	207 / 190	181 / 184	3.0		
1212	PURGE	FROM	33.1 TO	35.3					
1215	203.5	199.5	35.1	80.0	208 / 192	182 / 186	3.0		
1227	PURGE	FROM	33.1 TO	35.3					
1230	205.0	200.0	35.1	80.0	208 / 194	184 / 188	3.0		
1242	PURGE	FROM	33.5 TO	35.4					
1245	205.5	200.0	35.2	80.0	212 / 196	185 / 188	3.0		
1257	PURGE	FROM	33.5 TO	35.4					
1300	205.0	200.5	35.2	80.0	210 / 198	185 / 188	3.0		
	CONTINUE	TO SET	CONDITIONS	FOR TEST #44					
	EXTRACTED		49.0 CC		LR PH-5				
				SLIDE	COMPARATOR		4.0		

TITLE PERFORMANCE TEST # 43	ENGR. [illegible]
BAROMETER READING 13.79 @ 74°F	[illegible]
	DATE [illegible]-20-63
C-60 CATION [illegible] MEMBRANE #6	TEST NO. [illegible]
	PROJECT [illegible]
ELEC TEMP 200°F VAC PRESS 35.1 cm Hg	
FLUID H_2SO_4 [illegible] 40%	

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Thompson Ramo Wooldridge Inc.

TIME	T1 H2SO4 IN °F	T2 H2SO4 OUT °F	VACUUM PRESS. cm Hg	CIR H2O °F	VAC LINE °F / VAC MAN °F	T3 °F / T4 °F	FLOW	H2O CONDENSED cc	pH
1200	SETTING	CONDITIONS -	CONTINUING	FROM	TEST	#43			
1227	PURGE	FROM	29.0 TO	32.3					
1330	205.0	201.0	33.0	105.0	210 / 199	186 / 189	3.0		
	ADD	[illegible]	[illegible]	[illegible]	[illegible]				
* 1340	PURGE	FROM	29.0 TO	32.2					
1345	204.5	201.0	31.5	118.0	210 / 200	186 / 189	3.0	15.5	5
1357	PURGE	FROM	29.0 TO	31.5					
1400	203.0	197.0	31.0	120.0	211 / 200	185 / 188	3.0		
1412	PURGE	FROM	29.0 TO	31.5					
1415	203.0	199.0	31.1	120.0	210 / 200	184 / 187	3.0		
1427	PURGE	FROM	29.0 TO	31.5					
1430	203.0	199.0	31.2	120.0	210 / 200	184 / 188	3.0		
1442	PURGE	FROM	29.2 TO	31.5					
1445	203.0	199.0	31.2	120.0	210 / 200	184 / 188	3.0		
	ADD	[illegible]	[illegible]	[illegible]	[illegible]				
1457	PURGE	FROM	29.0 TO	31.5					
1500	202.0	197.5	31.1	120.0	209 / 200	183 / 187	3.0		
1512	PURGE	FROM	[illegible] TO	31.5					
1515	202.0	198.0	31.1	120.0	209 / 200	184 / 187	3.0		
1527	PURGE	FROM	[illegible] TO	31.5					
1530	202.5	198.0	31.1	120.0	209 / 200	184 / 187	3.0		
1542	PURGE	FROM	29.4 TO	31.5					
1545	202.5	198.5	31.1	120.0	209 / 200	184 / 187	3.0		
	STOP								
	EXTRACTED		44.5 CC		[illegible] PH	5			
				SLIDE	COMPARATOR	PH 4.3			

TITLE [illegible] TEST #44

BAROMETER READING 73.5 cm Hg @ 74°F

[illegible] [illegible] MEMBRANE #16

[illegible]

VAP PRESS. 31.1 cm Hg

FLUID [illegible] 80%

ENGR. [illegible]

DATE [illegible]

TEST NO. [illegible]

PROJECT [illegible]

TPFC-557

Thompson Ramo Wooldridge Inc.

TIME	T_1 H_2SO_4 IN °F	T_2 H_2SO_4 OUT °F	VACUM PRESS cm Hg	DIP H_2O °F	VAC LINE [illegible]	T_3 °F / T_4 °F	[illegible]	H_2O [illegible] CC	PH
0930	START	TO SET	CONDITIONS						
0942	PURGE	FROM	[illegible] TO	24.0					
0945	182.0	164.0	34.0	90.0	200/166	192/152	3.0	0	
0957	PURGE	FROM	30.6 TO	33.2					
1000	204.0	193.5	33.0	109.0	207/172	164/176	3.0	7.5	5
# 1027	PURGE	FROM	22.0 TO	26.5					
1030	206.0	201.0	26.4	140.0	209/180	187/186	3.0	7.0	5
1042	PURGE	FROM	24.6 TO	26.9					
1045	206.0	201.0	26.8	140.0	209/184	187/186	3.0		
1057	PURGE	FROM	25.2 TO	27.2					
1100	205.5	201.0	27.0	139.5	209/188	185/187	3.0		
1112	PURGE	FROM	25.5 TO	27.3					
1115	205.0	201.0	27.1	139.5	210/190	184/188	3.0		
1127	PURGE	FROM	25.7 TO	27.3					
1130	205.5	201.0	27.1	140.0	210/192	184/188	3.0		
1142	PURGE	FROM	26.3 TO	27.2					
1145	205.0	201.0	27.1	140.0	210	184/188	3.0		
1157	PURGE	FROM	25.4 TO	27.3					
1200	205.0	201.5	27.0	140.0	207/192	187/188	3.0		
1212	PURGE	FROM	[illegible] TO	27.5					
1215	204.5	200.0	27.4	139.5	207/192	184/188	3.0		
1227	PURGE	FROM	25.7 TO	27.5					
1230	204.0	200.0	27.2	140.0	208/192	184/188	3.0		
	CONTINUE	TO SET	CONDITIONS		FOR	TEST # 46			
	EXTRACTED		90.5 CC		H_2O = PH 5				
			SLIDE	CONDENSER		PH	4.0		

TITLE PERFORMANCE TEST # 45	ENGR. TH
BAROMETER READING 75.00 cm Hg @ [illegible] °F	JK
	DATE [illegible]
[illegible] WITH [illegible] MEMBRANE # 16	TEST NO. [illegible]
	PROJECT [illegible]
ELEC. TEMP. 200°F VAP PRESS [illegible] cm Hg	
FLUID [illegible]	

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Thompson Ramo Wooldridge Inc.

TIME	T_1 H_2SO_4 IN °F	T_2 H_2SO_4 OUT °F	VACUUM PRESS CM HG	CIR. H_2O °F	VAC. LINE °F / VAC. MAN. °F	T_3 °F / T_4 °F	INLET PRESS. CM HG	FLOW / H_2O CONDEN. CC	PH
1300	SETTING	CONDITIONS							
1312	PURGE	FROM	29.0 to	20.5					
1315	179.0	167.0	20.4	119.0	208 / 170	195 / 150	0	3.0 / 0	
1322	PURGE	FROM	22.2 to	29.0					
1325	196.5	184.0	22.5	126.0	208 / 172	158 / 164	0	3.0 / 12.0	5
1342	PURGE	FROM	22.2 to	25.0					
1345	205.0	197.5	24.4	140.0	208 / 182	171 / 182	0	3.0 / 15.5	5
* 1357	PURGE	FROM	22.0 to	25.0					
1400	190.0	187.0	25.0	140.0	208 / 186	167 / 178	54.2	1.0 / 11.0	
1412	PURGE	FROM	24.0 to	25.5					
1415	200.0	189.0	25.5	140.0	208 / 190	166 / 178	54.2	2.5	
1427	PURGE	FROM	24.0 to	[illegible]					
1430	206.0	193.0	26.0	140.0	210 / 194	169 / 18[illegible]	54.2	1.0	
1442	PURGE	FROM	22.4 TO	25.0					
1445	205.0	195.0	24.9	140.0	211 / 196	174 / 184	54.8	3.5	
1457	PURGE	FROM	22.3 to	25.5					
1500	201.5	192.5	25.3	140.0	210 / 196	174 / 182	54.4	3.5	
1512	PURGE	FROM	22.0 to	25.5					
1515	207.0	195.5	25.3	140.0	210 / [illegible]	175 / 184	54.6	3.5	
1527	PURGE	FROM	21.8 to	25.5					
1530	20[illegible].0	200.0	25.3	140.0	210 / 198	177 / 188	55.2	3.5	
1542	PURGE	FROM	22.2 to	25.5					
1545	209.0	201.0	25.5	140	212 / 200	180 / 192	54.8	4.0	
1557	PURGE	FROM	23.0 to	26.2					
1600	196.0	192.0	25.9	140.0	212 / 200	176 / 182	54.2	4.0	
	STOP								
	EXTRACTED		85.0 CC	@ PH 5					

TITLE PERFORMANCE TEST # 47

BAROMETER READING 75.12 CM HG @ 72°F

[illegible] MEMBRANE # 16

ELEC TEMP [illegible] [illegible] PRESS. [illegible] CM HG

FLUID [illegible]

ENGR. [illegible]

DATE 2-27-62

TEST NO. [illegible]

PROJECT [illegible]

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Thompson Ramo Wooldridge Inc.

Time	T_1 H_2SO_4 in °F	T_2 H_2SO_4 out °F	Vacuum Purge cm Hg	Cir. H_2O °F	Vacuum Line °F / [illegible] °F	T_3 °F / T_4 °F	Inlet Press. cm Hg	Flow / H_2O [illegible] cc	pH
0930	Setting [illegible]								
0945	Purge	From	23.0 to	2[illegible].0					
0948	172.0	181.0	26.3	134.0	202 / 168	150 / 164	0	3.0 / 2.5	1
0957	Purge	From	23.5 to	25.0					
1000	201.0	192.5	24.0	140.0	232 / 172	162 / 174	0	4.0 / 7.5	1
1012	Purge	From	20.0 to	23.5					
1015	203.0	196.5	22.3	127.0	206 / 180	121 / 180	0	4.0 / 10.[illegible]	2
1027	Purge	From	19.5 to						
1030	203.0	198.0	19.5	147.0	209 / 186	175 / 182	0	4.0 / 13.5	5
1057	[illegible]	[illegible]	[illegible]	[illegible]					
1100	206.0	201.0	21.5	147.0	210 /	179 / 182	0	4.9 / 15.5	5
☆ 1132	Purge	From	[illegible] to	24.0					
1135	203.5	196.5	23.8	140.0	210 / 182	178 / 184	88.0	3.0 /	
1147	Purge	From	22.5 to	26.0					
1150	202.5	196.0	25.3	140.0	210 / 174	170 / 1[illegible]	88.2	3.0 /	
1202	Purge	From	22.5 to	25.					
1205	201.0	195.0	25.3	140.0	211 / 197	176 / 182	90.0	2.0 /	
1208	Stop –	Hoses leaking							
	Extracted	29.0 cc.							

TITLE [illegible] #45
Barometer [illegible] 74.92 cm Hg @ 74 °F
C-60 [illegible] [illegible] Membrane #16
[illegible] Temp [illegible] Vap. Press.
FLUID H_2SO_4 Conc [illegible]

ENGR. [illegible]
DATE 2-28-6[illegible]
TEST NO. [illegible]
PROJECT [illegible]

TAPCO a division of
Thompson Ramo Wooldridge Inc.

FINANCIAL REPORT

for

FEBRUARY - 1963

(Contract NAS 3-2551)

Submitted by

NEW PRODUCT RESEARCH of TAPCO

(Attachment to Monthly Progress Report No. 8)

FINANCIAL REPORT

for

Contract NAS 3-2551

for

Period Ending February 28, 1963

	Current Month	Total To Date
TRW Engineering Hours	286.5	1697.0
TRW Costs and Commitments	$ 4,595	$ 26,680
Subcontractor Costs and Commitments	14,220	121,985
TOTAL	$ 18,815	$ 148,665

TPFC-557

Thompson Ramo Wooldridge Inc.

TIME	T1 H2SO4 IN °F	T2 H2SO4 OUT °F	VACUUM PRESS CM HG	CIR. H2O °F	VAC. LINE °F / VAC CHAMB °F	T3 °F / T4 °F	FLOW	H2O COLLECTED CC	PH
1230	SETTING CONDITIONS - CONTINUING FROM TEST #45								
	ADD 500 CC DIST H2O TO H2SO4								
1257	PURGE	FROM	21.8 TO	23.5					
1300	[illegible]	197.5	22.0	160.0	210/192	184/[illegible]	3.0	5.5	5
1312	PURGE	FROM	20.8 TO	22.0					
1315	204.5	200.5	21.7	160.0	211/196	186/188	3.0		
1327	PURGE	FROM	20.5 TO	22.0					
1330	206.0	201.0	21.6	160.0	212/198	18[illegible]/190	3.0		
	NO CONDENSATE APPEARING ON CONDENSER								
1330	CONDENSATE APPEARING VAPOR PRESS OSCILLATING								
1345	PURGE	FROM	[illegible] TO	22.0					
1348	206.0	202.0	22.0	160.0	212/198	18[illegible]/19[illegible]	3.0		
	VAPOR PRESS [illegible]								
1400	PURGE	FROM	20.0 TO	22.5					
1405	205.0	202.0	21.6	160.0	21[illegible]/198	188/[illegible]	3.0		
1415	PURGE	FROM	20.6 TO	22.5					
1418	204.5	201.5	21.9	160.0	210/198	188/191	3.0		
1430	PURGE	FROM	21.0 TO	22.5					
1433	[illegible]	[illegible]	21.9	160.0	210/198	187/190	3.0		
1445	PURGE	FROM	21.5 TO	22.5					
[illegible]	204.0	200.5	22.0	160.0	210/19[illegible]	18[illegible]/189	3.0		
1500	PURGE	FROM	21.5 TO	22.5					
1503	203.5	200.0	22.2	160.0	210/[illegible]	184/18[illegible]	[illegible]		
1515	PURGE	FROM	21.0 TO	22.5					
1518	203.0	200.0	22.2	160.0	212/198	185/18[illegible]	3.0		
1530	PURGE	FROM	21.4 TO	22.5					
1533	[illegible]	[illegible]	21.8	160.0	210/198	18[illegible]/[illegible]	3.0		
	STOP								
	EXTRACTED		120.0 CC	1B	PH. 5				

TITLE PERFORMANCE TEST #46
BAROMETER READING 29.95 [illegible]
C-60 CATION [illegible] MEMBRANE #16
DIST TEMP 200°F — VAC PRESS. 22.0 CM HG
FLUID H2SO4 [illegible] 40%

ENGR. TH
DATE [illegible]
TEST NO. [illegible]
PROJECT [illegible]